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Faculty of Engineering Department of Mechanical and Automotive Engineering BSc Hons (Eng) Advanced Automotive Systems Engineering Semester 8 First Sit - Final Examination 2026 Batch:5	
Module Code: ME4321	**Module Title: Advanced Automotive Systems Engineering**
Date: 12th August 2026	**Duration: 3h**
Examiner 1:	**S D R Perera**

Instructions to Candidates:

- *This is a closed book examination. No reference materials are allowed unless specified.*
- *This paper consists of five (5) questions in 7 pages. Answer all questions.*
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Q1. **i)** Primary emission-control techniques reduce pollutant formation inside the engine before combustion products enter the exhaust system. Critically discuss the following primary emission-control technologies with respect to their operating principles, advantages and limitations.

a) Electronic fuel injection with closed-loop lambda control. [04]

b) Exhaust gas recirculation (EGR). [04]

ii) Figure Q1 illustrates the typical variation of carbon monoxide (CO), unburned hydrocarbons (HC), oxides of nitrogen (NOx) and oxygen (O_2) emissions with air–fuel ratio for a spark-ignition engine. Using Figure Q1 and appropriate combustion principles, support your discussion using combustion chemistry and thermodynamic principles.

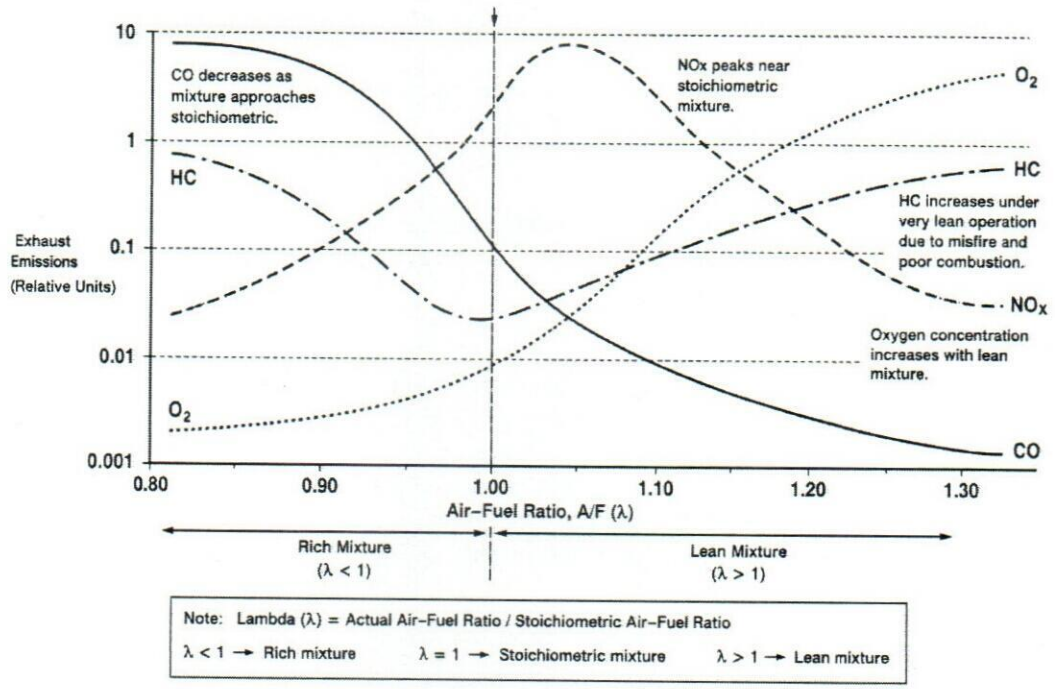


Figure Q1 – Emissions from an IC engine with air fuel ratio

a) Explain why carbon monoxide concentration decreases as the mixture changes from rich to stoichiometric conditions. [02]

b) Explain why hydrocarbon emissions increase under extremely lean operating conditions. [04]

c) Explain why oxides of nitrogen reach a maximum near the stoichiometric air–fuel ratio. [04]

d) Explain why oxygen concentration increases under lean combustion conditions. [02]

Total [20]

Q2. **i)** Modern passenger vehicles increasingly employ Gasoline Direct Injection (GDI) instead of Multi-Point Injection (MPI). Critically compare MPI and GDI with respect to the following engineering aspects: Injection pressure, Charge cooling, Volumetric efficiency, Knock resistance, Compression ratio, Fuel economy, Exhaust emissions [07]

ii) Modern GDI engines employ stratified charged combustion systems where the air fuel ratio is extremely lean. Explain three main combustion-system designs used to achieve efficient heterogeneous mixture preparation with the aid of neat, labelled sketches. [05]

iii) Gasoline Direct Injection engines are capable of operating in both homogeneous-charge and stratified-charge combustion modes. Explain the operating principles of these two combustion modes. Discuss: **[05]**
Air–fuel mixture formation, Injection timing, ignition timing, Typical operating conditions, Advantages and Limitations

Explain why stratified-charge operation is not employed under all engine operating conditions. **[03]**

Total [20]

Q3 **i)** Figure Q3 illustrates the exhaust after-treatment system of a modern Euro VI diesel engine. With the aid of the figure, explain the operating principles of the following components: [10]

- Diesel Oxidation Catalyst (DOC)
- Diesel Particulate Filter (DPF)
- Selective Catalytic Reduction (SCR)
- Ammonia Slip Catalyst (ASC)

Your discussion shall include: principal functions, catalyst materials, operating temperatures, advantages, limitations

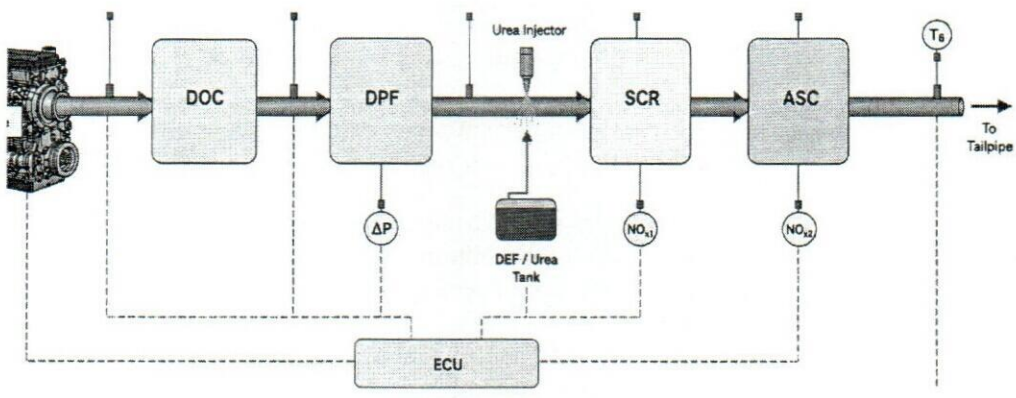
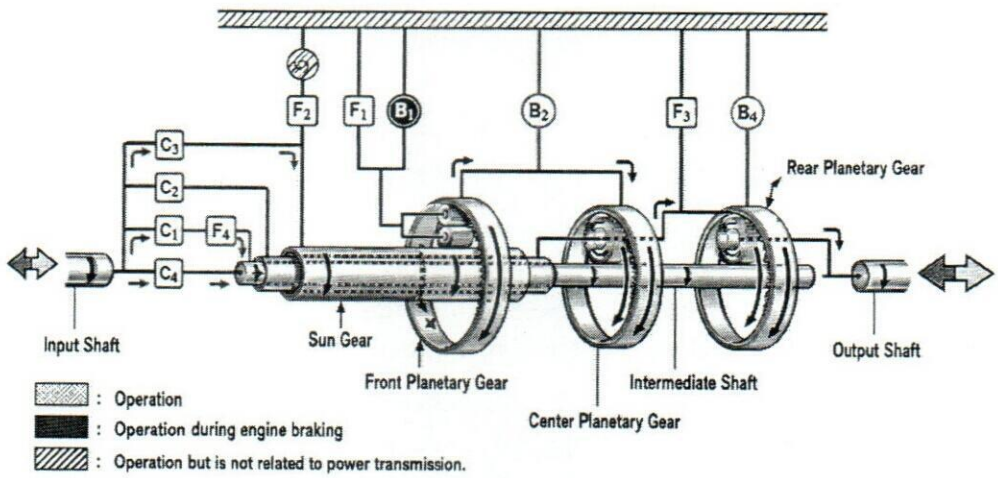


Figure Q3 – exhaust after-treatment system of a modern Euro VI diesel engine.

ii) The combination of planetary gears in the 3rd gear of an automatic transmission system is shown in Figure Q3(b). Determine the gear ratio. [10]

The No. of Sun Gear Teeth	33
Front Planetary Gear: The No of Pinion Gear Teeth Inner	19
Front Planetary Gear: The No of Pinion Gear Teeth Outer	18
The No. of Ring Gear Teeth	75
The No. of Sun Gear Teeth	26
Center Planetary Gear: The No. of Pinion Gear Teeth	20
The No. of Ring Gear Teeth	66
The No. of Sun Gear Teeth	26
Rear Planetary Gear: The No. of Pinion Gear Teeth	20
The No. of Ring Gear Teeth	66



C_1	C_2	C_3	C_4	B_1	B_2	B_3	B_4	F_1	F_2	F_3	F_4
○	○	○	○	(○)	○	△	○	○	○	○	○

○: Operation
(○): Operation during engine braking (only in the S mode [3rd])
△ : Operation but is not related to power transmission

Figure Q3 (b) –combination of planetary gears in the 3rd gear

Total [20]

Q4 Cerium oxide (CeO_2) is one of the most expensive materials used in modern three-way catalytic converters. Explain the role of cerium oxide during catalytic reactions under transient engine operating conditions support the following functions of the catalytic converter. Your discussion shall include balanced chemical equations where appropriate.

a) oxygen storage mechanism; [02]
b) oxygen release mechanism; [02]
c) interaction with platinum, palladium and rhodium; [02]
d) oxidation of carbon monoxide; [02]
e) oxidation of unburned hydrocarbons; [02]
f) reduction of oxides of nitrogen; [02]

Particulate matter (PM) and oxides of nitrogen (NOx) are generally regarded as the two most important pollutants emitted by compression-ignition diesel engines. [08]

Explain why these pollutants are characteristic of diesel combustion despite diesel engines normally operating with excess air.
Your answer should relate combustion temperature, heterogeneous mixture formation, diffusion combustion and local fuel-rich regions to pollutant formation.

Total [20]

Q5 i) The Proton Exchange Membrane Fuel Cell is currently the preferred fuel cell technology for automotive applications. With the aid of a neat labelled sketch, explain the construction and operating principle of a PEM fuel cell. Your discussion shall include: [06]

- Hydrogen supply system
- Air supply system
- Anode
- Cathode
- Proton Exchange Membrane
- Catalyst layer
- Bipolar plates
- Water management
- Thermal management.

Write the electrochemical reactions occurring at: the anode and the cathode [02]

ii) The performance of a Fuel Cell Electric Vehicle depends not only on the fuel cell but also on the complete electric propulsion system. With the aid of a block diagram, explain the functions of the following components: [04]

- Hydrogen storage system
- Fuel cell stack
- DC–DC converter
- Lithium-ion battery
- Inverter
- BLDC traction motor
- Regenerative braking system

iii) Explain how electrical energy flows through the vehicle during: [03]

- vehicle starting,
- normal cruising,
- rapid acceleration,
- regenerative braking.

iv) Hybrid-electric vehicles may be broadly classified into three principal architectures. With the aid of neat, labelled sketches, explain the operating principles of: [05]

- Series Hybrid Electric Vehicle
- Parallel Hybrid Electric Vehicle
- Series–Parallel (Power-Split) Hybrid Electric Vehicle

Total [20]

End of Examination paper

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Faculty of Engineering & Technology Department of Mechanical and Automotive Engineering BSc. Hons. (Eng.) in Mechanical Engineering Semester 4 First Sit - Final Examination 2026 Batch : 7	
Module Code: ME2323	**Module Title: Dynamics of Mechanical Systems**
Date: 08 June 2026	**Duration: 3 hours**
Examiner 1: **Examiner 2:**	**S. R. Herath**

Instructions to Candidates:

- *This is a closed book examination.*
- *This paper consists of four(4) questions and a formula sheet in 4 pages. Answer all questions.*
- *The marks allocated to each question are listed in the column on the far right. Final mark of the question paper will be calculated out of 100.*
- *Use only the provided answer booklet, additional sheets, and graph papers for your answers.*
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Q1 A vibrating system consists of a 20 kg mass, a spring with stiffness 2 kN/m and a viscous damper with damping constant 40 Ns/m. Determine:

a) the damping ratio [05]

b) the damped natural frequency [05]

c) the logarithmic decrement [05]

d) the ratio of two successive amplitudes [05]

Total [20]

Q2. Figure 1 shows a slider crank mechanism. The crank radius is r, and the connecting rod length is l. θ is the crank angle as shown. ω is the angular velocity of the crank. ***x*** is the displacement of slider **A** measured from the **crank axis O** which is perpendicular to the plane of the paper.

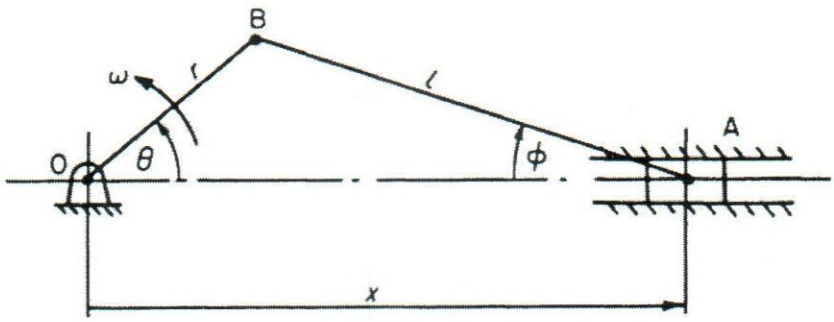


Figure 1

a) Write an expression for x in terms of r, l and θ. [05]

b) Derive an expression for velocity of Slider A, $\dot{x}$, in terms of r, l, θ and ω. [10]

c) A slider-crank mechanism has a crank radius of 160 mm, and a connecting rod 500 mm long. The crank rotates at a steady speed of 4500 rev/min. Find the velocity of slider **A**, when the crank has turned through an angle of 40° using **instantaneous centre** method. Also find the velocity using the equation derived in b) and compare the results. [25]

Total [40]

Q3. The turning-moment diagram for one cycle of a multi-cylinder engine shows the following intercepted areas in mm^2 , -5, +63, -42, +51, -49, +36, -58, +42, -38 above and below the mean torque line. The vertical and horizontal scales are 1 mm equal to 1000 Nm and 5° respectively.

a) Sketch the turning moment diagram for this engine about mean torque. [05]

b) If the mean speed is 500 rev /min and the overall fluctuation of speed is not to exceed 1.5 per cent, determine the moment of inertia of the flywheel. [20]

Total [25]

Q4. Figure 2 shows a compound gear train. The number shown with each gear is the number of teeth in each. If gear A rotates with a speed of 1200 rev/min clockwise as shown in the figure, determine the revolutions per minute and direction of rotation of gear G. [15]

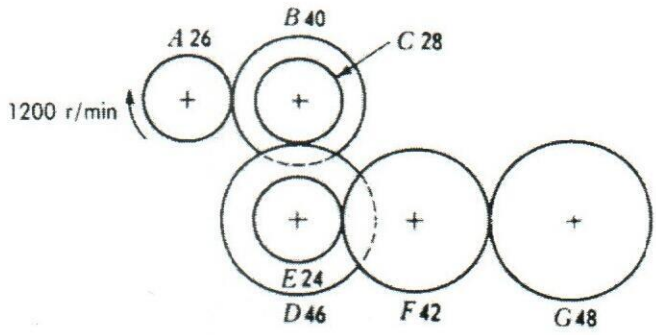


Figure 2

Total [15]

End of the Question Paper

Formula Sheet

Theory of Vibrations:

$$\omega_n = \sqrt{\frac{k}{m}}$$

$$c_c = 2\sqrt{km}$$

$$\xi = \frac{c}{c_c}$$

$$\omega_d = \omega_n\sqrt{1-\xi^2}$$

$$\delta = \frac{2\pi\xi}{\sqrt{1-\xi^2}}$$

$$\frac{x_1}{x_2} = e^{\delta}$$

Binomial theorem for the square root term:

$$\sqrt{\left(1-\frac{r^2}{l^2}\sin^2\theta\right)} = \left(1-\frac{r^2}{2l^2}\sin^2\theta-\frac{r^4}{8l^4}\sin^4\theta-\ldots\right)$$

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Faculty of Engineering Department of Mechanical and Automotive Engineering BSc. Hons. (Eng.) in Mechanical Engineering BSc. Hons. (Eng.) in Automotive Engineering Semester 4 - First Sit - Final Examination 2026 Batch: 07	
Module Code: ME2324	**Module Title: Automobile Technology II**
Date: 06/06/2026	**Duration: 03hrs**
Examiner 1: **Examiner 2:**	**Ms. Sasitha Eldeniya**

Instructions to Candidates:

- *This is **a closed book** examination. No reference materials are allowed unless specified.*
- *This paper consists of **five (05) questions** and eight (08) pages. **Answer all questions**.*
- *The marks allocated to each question are listed in the column on the far right. Final mark of the question paper will be calculated out of 100.*
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Q1 i) Discuss the functions of an Automobile Clutch. [02]

ii) List down two types of "Automobile clutch operating mechanism" and briefly explain them. [04]

iii) A plate clutch having a single driving plate with contact surfaces on each side is required to transmit 110 kW at 1250 r.p.m. The outer diameter of the contact surfaces is to be 300 mm. The coefficient of friction is 0.4.

a) Determine the inner diameter of the friction surfaces if the uniform pressure is 0.17 N/ mm^2. [07]

b) Assuming the same dimensions and the same total axial thrust, determine the maximum torque that can be transmitted and the maximum intensity of pressure when uniform wear conditions have been reached. [04]

iv) Describe the working of a synchromesh transmission. [03]

v) Identify the components of a "Synchromesh Transmission" depicts by the Figure 01. [05]

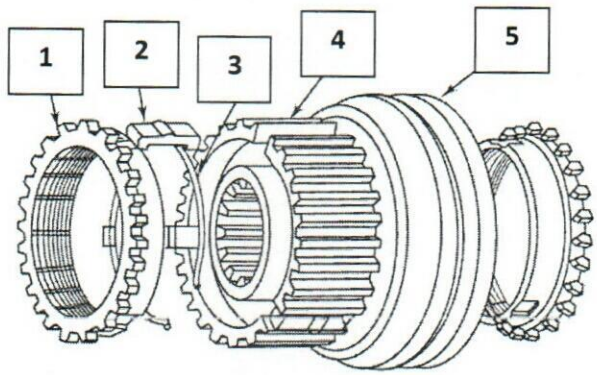


Figure 01

Total [25]

Q2. i) Describe the function and the torque multiplication scenario of a torque converter. [03]

ii) Name the components depicted by the Figure 02. [03]

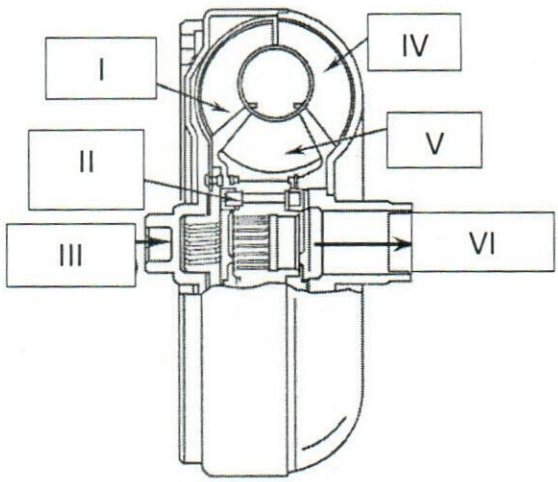


Figure 02

iv) List down the main components which can be found in a Simple Planetary Gear Set with a simple sketch. [04]

v) What is the purpose of using an Overdrive in a vehicle? Explain. [05]

Total [15]

Q3. **i)** What is the principle of Correct Steering? [02]

ii) Write down the three main components of the "Automobile Steering Systems" and explain the functions of it. [06]

iii) Classify the two types of steering mechanisms for Automobiles. Briefly explain them. [04]

iv) Determine the components of the "Conventional Steering Linkage" assembly illustrated by the Figure 3. [05]

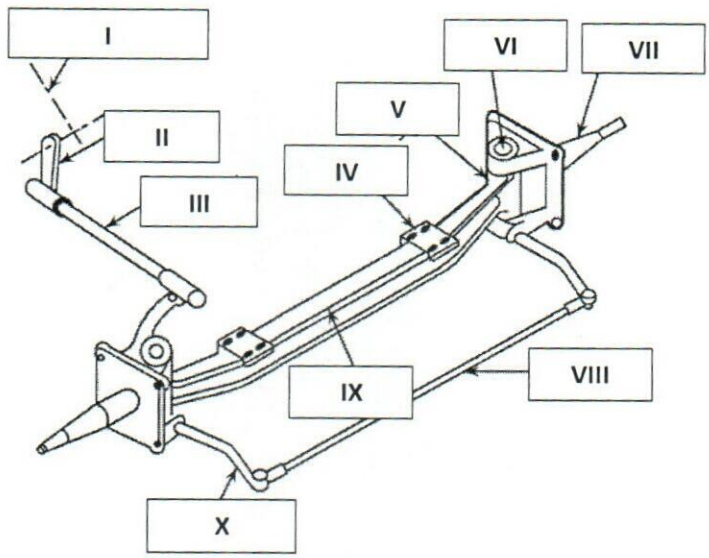


Figure 03

v) Write a brief description on the following. [03]

a) Camber
b) Caster
c) Toe

Total [20]

Q4. **i)** Name five (05) requirements for good braking system. [03]

ii) Differentiate between a leading shoe and a trailing shoe in a brake drum. [02]

iii) State three (03) types of drum brakes available in Automobiles. [03]

iv) Identify the following components of a "Disc Brake Assembly" in the Figure 4. [07]

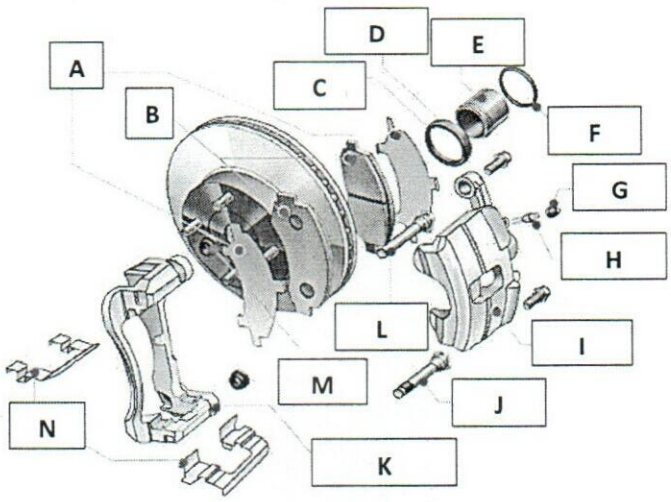


Figure 04

v) State the purpose of the antilock brake system (ABS). Explain the basic operation of ABS. [05]

Total [20]

Q5. **i)** Define the "Sprung Weight" and "Un-sprung Weight". [03]

ii) List two (02) types of suspension systems and briefly describe them. [04]

iii) List down the following components of a "Hotchkiss Drive" in the Figure 05. [05]

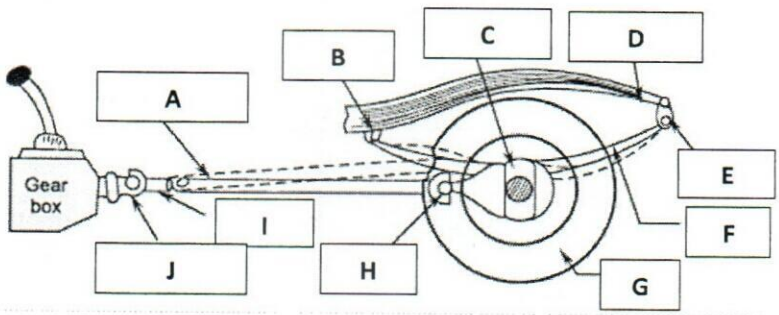


Figure 05

iv) Write short description on the following. [08]

a) Tripod Joint
b) Three quarter floating axle
c) Double reduction differential
d) Torque tube drive

Total [20]

Table 01 – Formula Sheet	
Mean radius for uniform pressure,	$R = \frac{2}{3}\left[\frac{(r_1)^3 - (r_2)^3}{(r_1)^2 - (r_2)^2}\right]$
Mean radius for uniform wear,	$R = \left[\frac{r_1 + r_2}{2}\right]$
Intensity of pressure at the outer radius,	$P_{min} \times r_1 = C$
Intensity of Pressure at the inner radius,	$P_{max} \times r_2 = C$
Average pressure on the contact surface,	$P_{av} = \frac{W}{\pi[(r_1)^2 - (r_2)^2]}$
Force acting on the friction surface,	$W = 2\pi C(r_1 - r_2)$
Frictional Torque,	$T = n\mu WR$

END OF THE QUESTION PAPER

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Faculty of Engineering & Technology
Department of Mechanical & Automotive Engineering
BSc. Hons. (Eng.) in Mechanical Engineering
BSc. Hons. (Eng.) in Automotive Engineering
Semester 4 First Sit – Final Examination 2026

Module Code: ME2322	**Module Title: Fluid Dynamics**
Date: 02n^{d} June 2026	**Duration: 03 Hours**
Examiner 1: **Examiner 2:**	**Asiri Manchanayaka**

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Q1. (i) Explain how the dynamic viscosity of liquids and gases changes with temperature, using a suitable graphical representation. **(02 Marks)**

(ii) The viscosity of a fluid is determined by using a viscometer consisting of two concentric cylinders, each 50 cm in length, as illustrated in Figure Q1. The inner cylinder has an outer diameter of 15 cm, while the clearance between the two cylinders is 0.12 cm. The space between the cylinders is completely filled with test fluid. During operation, the inner cylinder rotates at a speed of 400 rpm, and the corresponding torque required is measured as 2.1 N·m. Assume that the fluid is Newtonian and that the viscous effects at the top and bottom ends of the inner cylinder are negligible.

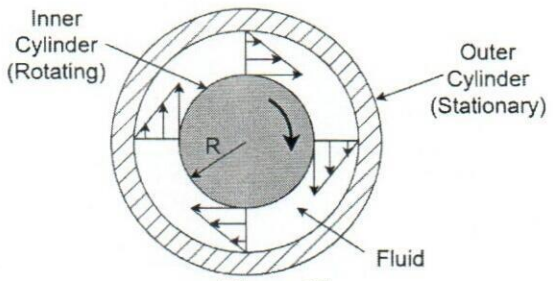


Figure Q1

(a) Calculate the shear stress generated in the fluid layer adjacent to the outer surface of the inner cylinder due to the applied torque. **(06 Marks)**

(b) Determine the gradient of the velocity profiles shown in the figure. **(06 Marks)**

(c) Calculate the viscosity of the fluid. **(06 Marks)**

Q2. Kerosene at 30 ^{0}C is transferred from a tanker to a large storage tank at a rate of 23 m^3/h through an 850-meter-long, 63.5-mm diameter commercial steel piping system. This system includes four fully open gate valves, two fully open globe valves, and 16 standard 90^0 flanged elbows. The elevation difference between the oil surface in the tanker and the oil surface in the storage tank is maintained at 35 m, with both the tanker and the storage tank being exposed to atmospheric pressure. Take the density and viscosity of kerosene at 30 ^{0}C are 820 kg/ m^3 and = 1.7×10^{-3} kg/m.s.

The loss coefficient (K_L) values are as follows.

Entrance: 0.8

Exit: 1.0

standard 90^0 flanged elbow: 0.3

Fully open globe valve: 10

Fully open gate valve: 0.15

(i) Determine the velocity of crude oil in the piping system. **(02%)**

(ii) Is the flow through the piping system laminar or turbulent? Explain. **(02%)**

(iii) Determine the total head loss in the piping system. **(08%)**

(iv) Calculate the power of the pump required to operate the system. Assume that the pump is expected to operate with 0.7 efficiency. **(08%)**

03. (i) Two common methods of improving fuel efficiency of a vehicle are to reduce the drag coefficient and the frontal area of the vehicle. Consider the truck shown in figure Q3 whose width (W) and height (H) are 2.59 m and 4.27 m, respectively, with a drag coefficient of 0.72. Assume the car is driven 36,000 km a year at an average speed of 60 km/h.

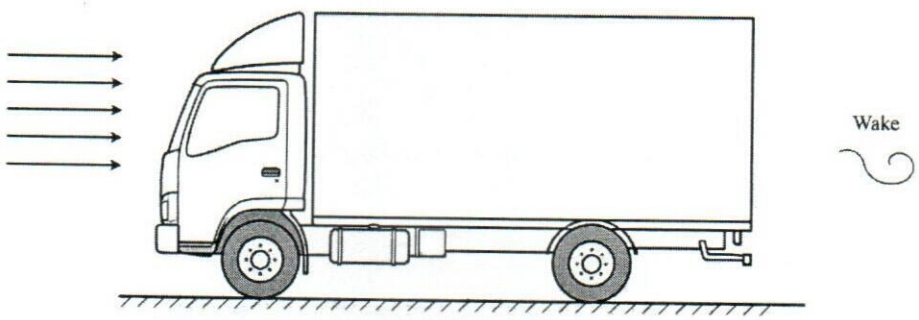


Figure Q3

(a) Calculate the drag force acting on the truck. Assume the density of air is 1.23 kg/m^3. **(04 Marks)**

(b) Determine the annual energy input required for the truck to overcome the drag force calculated previously, assuming that the overall efficiency of the truck's drivetrain is 27%. **(04 Marks)**

(c) Determine the amount of fuel and money saved per year as a result of reducing the truck height to 4.00 m while keeping its width the same. Take the density and price of diesel to be 0.82 kg/L and 300 Rs/L, respectively. The heating value of gasoline is 44,000 kJ/kg. **(04 Marks)**

(ii) Consider a light plane that has a total weight of 11,000 N and a wing area of 39 m^2 and whose wings be similar to the NACA 23012 airfoil with no flaps.

(a) Determine the takeoff speed at an angle of attack of 5^0 at sea level. The density of standard air at sea level is 1.225 kg/m^3. **(04 Marks)**

(b) What is the minimum "safe" takeoff speed? **(04 Marks)**

04. (i) Wind ($\rho = 1.204$ kg/m^3) blows through a HAWT wind turbine of rotor diameter is 72.0 m. The combined efficiency of the gearbox and generator is 84 percent. For a power coefficient of 0.42, estimate the electrical power production when the wind blows at 7.9 m/s. **(05%)**

(ii) A Pelton wheel is used to produce hydroelectric power. The average radius of the wheel is 1.7 m, and the jet velocity is 98 m/s from a nozzle of exit diameter equal to 9.0 cm. The turning angle of the buckets is 165°.

(a) Calculate the volume flow rate through the turbine in m^3/s. **(05%)**

(b) Determine the optimum rotation rate (for maximum power) of the wheel in rpm. **(05%)**

(c) Calculate the output shaft power in MW if the efficiency of the turbine is 85 percent. **(05%)**

05. The drag force F_D acting on an automobile depends on the vehicle's characteristic length L, the air velocity v around the automobile, the air density ρ, and the air viscosity μ.

(i) Apply the method of repeating variables to develop dimensionless relationship among these parameters. (develop Π terms) **(12 Marks)**

(ii) Manipulate the resulting Π terms as necessary to obtain a meaningful relationship. **(04 Marks)**

(iii) **(04 Marks)**

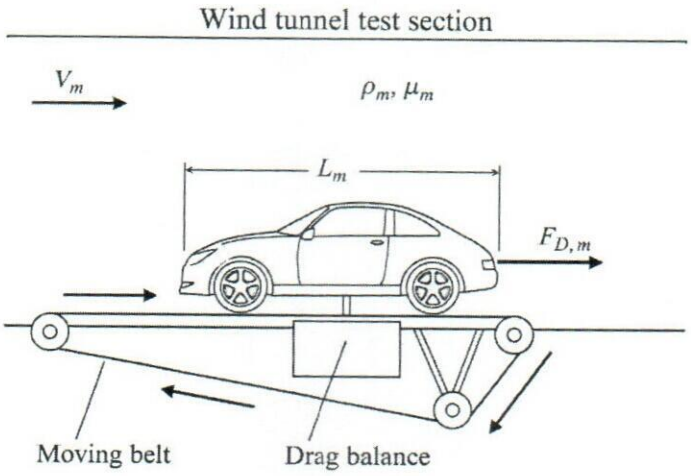


Figure Q5

The aerodynamic drag of a new sports car is to be predicted at a speed of 100 km/h at an air temperature of 25°C. Automotive engineers build a one-third scale model of the car as shown in the figure Q5 to test in a wind tunnel. The temperature of the wind tunnel air is also 25°C. The drag force is measured with a drag balance, and the moving belt is used to simulate the moving ground (from the car's frame of reference). Determine how fast the engineers should run the wind tunnel to achieve similarity between the model and the prototype.

End of the Question Paper

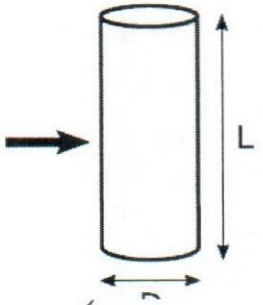
Data Sheet

Drag Coefficients

(1) Cylindrical Rod perpendicular to flow

L/D	C_D
1	0.6
2	0.7
5	0.8
10	0.9
40	1.0
Higher values	1.2

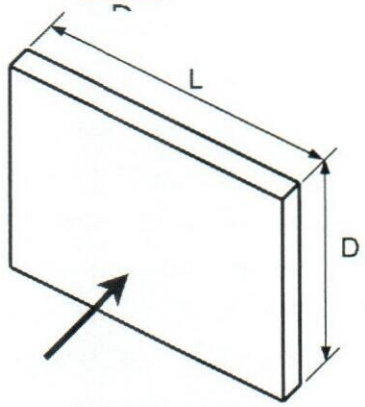
Reference area = LD



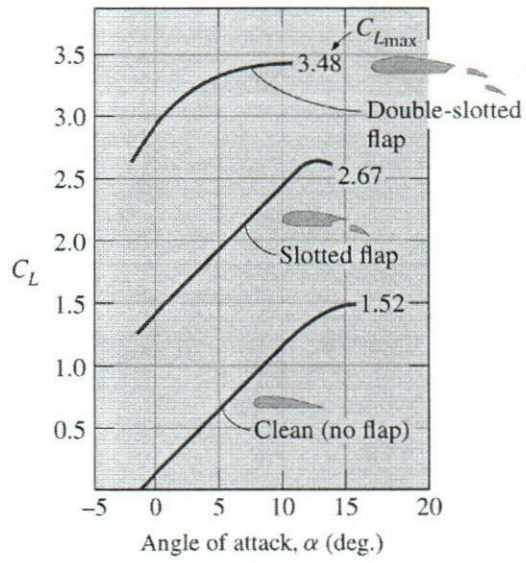
(2) Thin rectangular plate

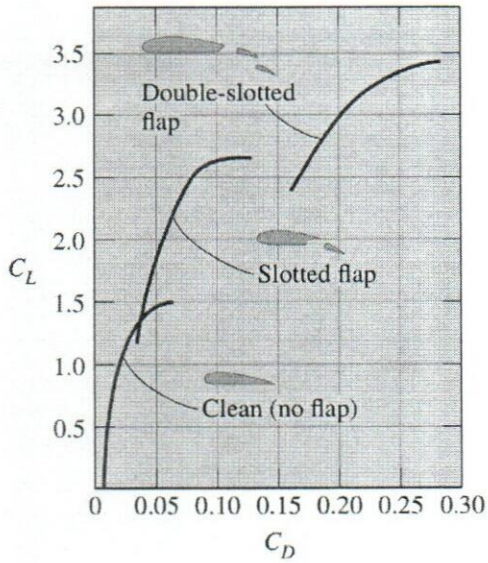
L/D	C_D
1	1.15
2	1.16
5	1.20
10	1.22
30	1.62
Higher values	1.98

Reference area = LD

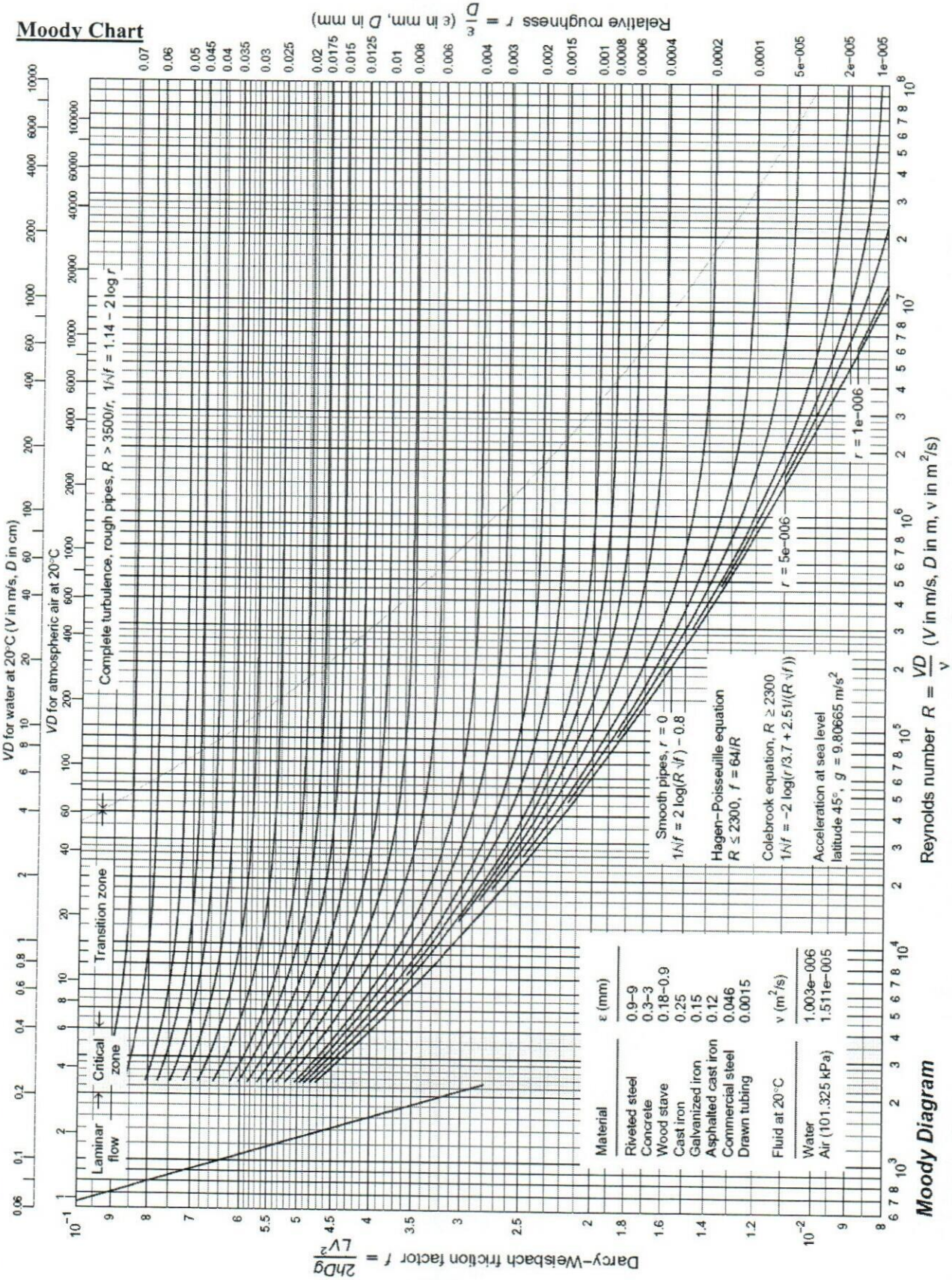


Effect of flaps on the lift and drag coefficients of an airfoil for NACA 23012





Moody Chart



Moody Diagram

Some common established nondimensional parameters

Name	Definition
Mac Number (Ma)	$\frac{v}{c}$
Nusselt number (Nu)	$\frac{Lh}{k}$
Reynolds number (Re)	$\frac{\rho v L}{\mu}$
Prandtl number (Pr)	$\frac{\mu C_P}{k}$
Power Number (N_P)	$\frac{\dot{W}}{\rho D^5 \omega^3}$
Euler Number (Eu)	$\frac{\Delta P}{\rho v^2}$

Losses in Pipes

Major $\Delta P_L = h_L \rho g$

$$h_{L(Major)} = f \frac{L}{D} \frac{v^2}{2g}$$

Minor $$h_{L(MInor)} = k \frac{v^2}{2g}$$

Friction factor in pipes

Laminar Flow $$f = f(\mathrm{Re}) = \frac{64}{\mathrm{Re}}$$

Turbulent Flow

$$\frac{1}{\sqrt{f}} = -2.0 \log\left(\frac{e/D}{3.7} + \frac{2.51}{\mathrm{Re}\sqrt{f}}\right)$$ Colebrook developed Eq.

Ideal Shaft power of a Pelton wheel

$$\dot{W}_{\text{ideal}} = \rho \omega r \dot{V}\left(V_j - \omega r\right)\left(1 - \cos\beta\right)$$

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CINEC CAMPUS
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Faculty of Engineering & Technology
Department of Mechanical Engineering
BSc. Hons. (Eng.) in Mechanical Engineering
Semester 4 First Sit - Final Examination 2026
Batch : 07

Module Code: ME2325	**Module Title: Strength of Materials**
Date: 28/05/2026	**Duration: 3 hrs**
Examiner 1:	**Dr. Thilini De Silva**

Instructions to Candidates:

- *This is a closed book examination. No reference materials are allowed unless specified.*
- *This paper consists of five (05) questions and 04 pages. Answer all questions.*
- *The marks allocated to each question are listed in the column on the far right. Final mark of the question paper will be calculated out of 100.*
- *Use only the provided answer booklet, additional sheets, and graph papers for your answers.*
- *Write clearly and legibly. Use a blue or black pen only.*
- *Write your student number on all sheets.*
- *Start each question on a new page in the answer booklet, answer sheets. Clearly indicate the question number at the top of the page.*
- *If parts of the same question are written discontinuously in non-consecutive sheets, ensure that each part is relevantly labelled with its corresponding question number.*

Q1. i) Briefly explain the difference between tensile stress and compressive stress. [04]

ii) Determine the change in length, width, and thickness of a steel bar which is 4 m long, 30 mm wide and 20 mm thick and it is subjected to an axial pull of 30 kN in the direction of its length. Take modulus of elasticity and Poisson's ratio of steel as 200 GPa and 0.3, respectively. [06]

iii) Determine the minimum diameter of a steel wire, which is used to raise a load of 4 kN if the stress in the rod is not to exceed 95 MPa. [04]

iv) The tensile stresses at a point across two mutually perpendicular planes are 120 N/mm^2 and 60 N/mm^2, as shown in ***Figure Q1 (iv)***. Determine the normal, tangential, and resultant stresses on a plane inclined at 30° to the axis of the minor stress.

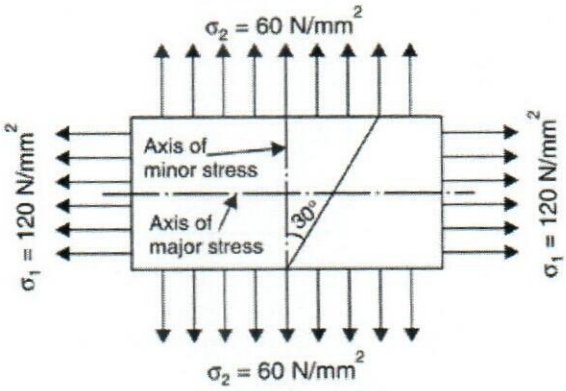


Figure Q1 (iv)

[06]

Q2. i) What is the meaning of the center of gravity of a body? [02]

ii) Find the centroid of the cross section shown in ***Figure Q2 (i)***.

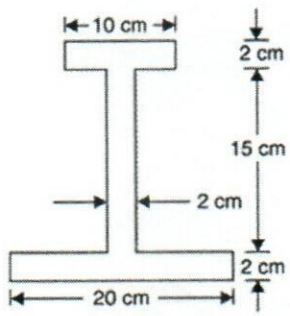


Figure Q2 (i)

iii) A semi-circular area is removed from the trapezoid as shown in ***Figure Q2 (iii).*** Determine the centroid of the cross section. [06]

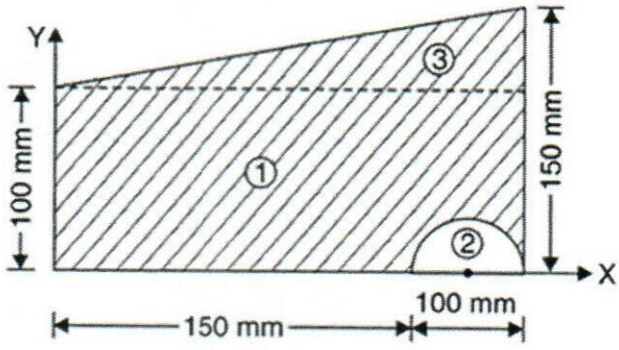


Figure Q2 (iii)

iv) Briefly explain any two types of beams based on the support conditions with suitable sketches. [08]

Q3. i) A cantilever beam of length 4 m carries a gradually varying load, zero at the free end to 2 kN/m at the fixed end. Draw the shear force diagram and bending moment diagram for the cantilever beam. [04]

ii) A rectangular beam 200 mm deep and 300 mm wide is simply supported over a span of 8 m. What uniformly distributed load per meter the beam may carry, if the bending stress is not to exceed 120 N/mm^2? [10]

Q4. i) Determine the ratio of the weights of two shafts made of the same material and having equal lengths, both subjected to the same applied torque. The first shaft has a solid circular cross-section, whereas the second shaft has a hollow circular cross-section with an internal diameter equal to $\frac{2}{3}$ of its external diameter. Assume that the maximum shear stress induced in both shafts is identical. [10]

ii) Determine the diameter of a solid steel shaft that will transmit power of 90 kW at 160 r.p.m. Also, determine the length of the shaft if the twist must not exceed 1° over the entire length. The maximum shear stress is limited to 60 N/mm^2. Take the value of modulus of rigidity as 8×10^4 N/mm^2. [10]

Q5. i) The tensile stresses at a point across two mutually perpendicular planes are 120 N/mm^2 and 60 N/mm^2. Determine the normal, tangential, and resultant stresses on a plane inclined at 30° to the axis of the minor stress using Mohr's circle method. [10]

ii) Determine the maximum vertical deflection at the midpoint of a simply supported beam of span 4 m subjected to a concentrated load W acting at the center of the span, given that the angular rotation (slope) at each support is limited to 1°. [10]

Total [100]

End of the Question Paper

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Faculty of Engineering & Technology

Department of Mechanical and Automotive Engineering

BSc Hons (Eng) Hybrid Electric and Alternative Energy Vehicles

Semester 6 First Sit - Final Examination 2026

Batch 6:

Module Code: ME3229	**Module Title: Hybrid Electric and Alternative Energy Vehicles**
Date: 25 May 2026	**Duration: 3h**
Examiner:	**S D R Perera**

Instructions to Candidates:

- *This is a closed book examination. No reference materials are allowed unless specified.*
- *This paper consists of five (5) questions in 3 pages. Answer all questions.*
- *The marks allocated to each question are listed in the column on the far right. Final mark of the question paper will be calculated out of 100.*
- *Use only the provided answer booklet, additional sheets, and graph papers for your answers.*
- *Write clearly and legibly. Use a blue or black pen only.*
- *Write your student number on all sheets.*
- *Start each question on a new page in the answer booklet, answer sheets. Clearly indicate the question number at the top of the page.*
- *If parts of the same question are written discontinuously in non-consecutive sheets, ensure that each part is relevantly labelled with its corresponding question number.*

Q1. A parallel HEV has a downsized engine, motor/generator, and a battery. The battery supplies energy to the motor/generator for propulsion assistance. The vehicle works in cruise condition for 40 mins at a speed of 30 (m/s) with a combined engine and electric motor propulsion. The required traction power is 14.2 (kW). In this span, the engine's BSFC is 280 g/kWh and the battery has 2500 kJ energy, of which travel consumes 60%. Calculate the fuel efficiency in terms of liters per kilometer. **[20]**

You may assume that motor mechanical efficiency and transmission efficiency are 88% and 85%, respectively. Assume the engine mechanical efficiency is 100%. Fuel heating value is 45.8 (MJ/kg) and fuel density is 737 (kg/m^3).:

Q2. **i)** Classify hybrid configurations according to the power flow and explain with relevant sketches their operating principle. **[08]**

ii) Sketch a schematic diagram and explain the configuration of a fuel cell electric hybrid vehicle with a peak power source. **[12]**

Total **[20]**

Q3 **i)** Briefly explain the main power flow path of fuel cell electric hybrid vehicles. **[8]**

ii) By means of a flow diagram, explain how the control objectives given below are achieved in a fuel cell electric hybrid vehicle

a) Motor power meet driver demand **[4]**

b) PPS energy remain within optimal limits **[4]**

c) Fuel cell operate within its high efficiency region **[4]**

Total **[20]**

Q4 In a typical hybrid vehicle application, the following inputs are being received by the EMS. **[20]**

- Driver torque or power demand
- Vehicle speed
- Battery SOC
- Engine operating condition
- Motor limits and efficiency maps

Based on the inputs received to the EMS, a rule-based control derived from engineering knowledge and system characteristics can be defined. These rules determine the power distribution between the engine and the electric motor under different operating conditions. Write typical operating Rules for a hybrid vehicle

Q5 **i)** State why is SOC important in electric vehicles? **[3]**

ii) A 50 Ah battery discharges at 5 A for 2 hours. Calculate SOC drop **[3]**

iii) The SOC of a battery evolves as **[14]**

$$SOC_k = SOC_{k-1} - \frac{I\Delta t}{C}$$

Compute updated SOC using Kalman filter using following data

a) ($SOC_0 = 0.8$)
b) Battery capacity ($C = 50$, Ah)
c) Current ($I = 5A$)
d) ($\Delta t = 1h$)
e) ($Q = 0.001$), ($R = 0.01$)
f) Measured SOC ($z_1 = 0.72$)
g) Initial covariance ($P_0 = 0.01$)

Total [20]

End of the Question Paper

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Faculty of Engineering & Technology Department of Mechanical and Automotive Engineering BSc. Hons. (Eng.) in Automotive Engineering Semester 06 First Sit - Final Examination 2026 Batch : 06	
Module Code: ME3227	**Module Title: Automobile Repair and Maintenance**
Date: 23/05/26	**Duration: 3 Hrs**
Examiner **Examiner**	**Inupa Fernando**

Instructions to Candidates:

- *This is a closed-book examination. No reference materials are allowed unless specified.*
- *This paper consists of **five (5) questions and 05 pages.** Answer all questions.*
- *The marks allocated to each question are listed in the column on the far right. Final mark of the question paper will be calculated out of 100.*
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Q1 **i)** Safety is not just a buzzword on a poster in the work area. Safe work habits can reduce accidents and injuries, ease the workload and protect employees. Cleaning is a core part of automotive workshops, and proper protocols must be followed during cleaning processes.

a) What are the main types of cleaning methods and processes used in vehicle service? [02]

b) What are the 4 main classes of fire extinguishers? Explain what each class of fire extinguisher is used for. [04]

c) [06]



Identify this label and describe 5 workshop safety principles associated with handling chemical/materials related to it.

ii) A customer brings a Hyundai petrol car to a garage, complaining that the engine is running poorly. The vehicle has approximately 245,000 km on the odometer. The customer mentions the following problems: [08]

- Loss of engine power
- Difficulty starting the engine in the morning
- Rough idle
- Increased fuel consumption
- Bluish grey smoke from the exhaust occasionally

Upon inspection, the technician finds excessive carbon buildup and oil consumption. Deduce the main cause of these problems and explain the test by which the diagnosis can be verified.

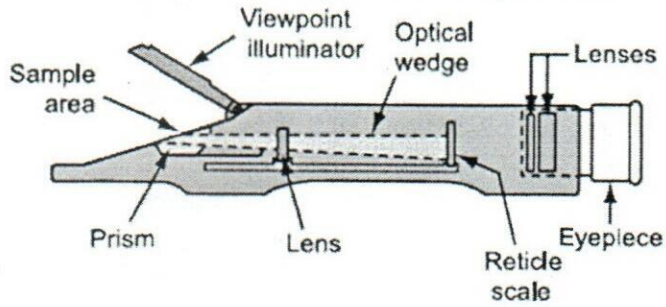
Total [20]

Q2.

i) a) What is a Repair Order? List 5 reasons why a repair order is important. [03]

b) List the main information that must be present in a repair order [04]

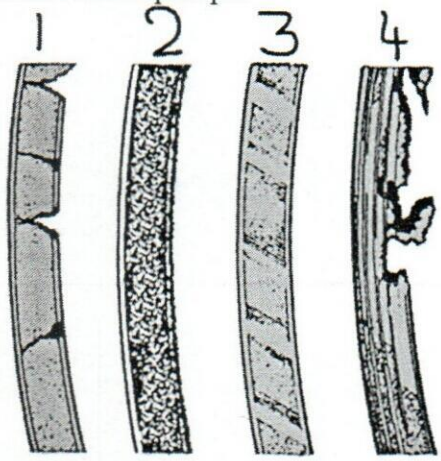
c)



Name the following instrument and briefly explain how the coolant condition of a motorcar can be inspected using this instrument. [05]

ii) Drive belts have been used for many years. V-belts and V-ribbed belts are used to drive water pumps, power steering pumps, air conditioning pumps, compressors and emission control pumps.

a)



What are the 4 conditions shown in the drive belts above? [02]

b) Explain the typical procedure of removing, replacing and adjusting a drive belt. [06]

Total [20]

Q3. **i)** a) Briefly describe how the following problems can occur in a vehicle with disc brakes.

1. Brake pedal Pulsations under normal braking.

2. Pulls to one side when braking

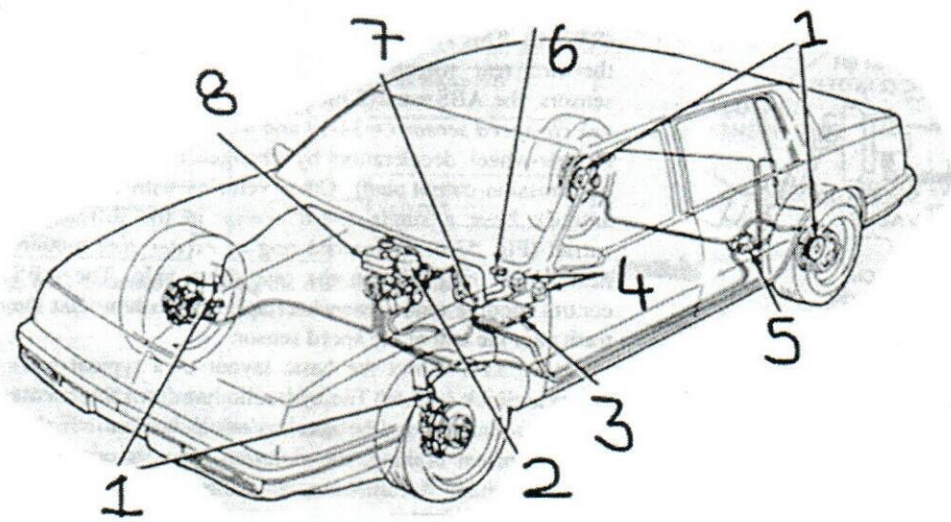
3. Brakes fail to release

4. Rattle or squealing brakes

5. Fluid leaking from caliper

[06]

ii) **a)**



Identify the components of a vehicle with ABS combined with the hydraulic brake booster and master cylinder, and explain the function of each component [08]

b) Explain in detail the process of changing up and bleeding hydraulic brake fluid in a vehicle. [06]

Total [20]

Q4. **i)** a) Briefly explain the process of testing a 12V vehicle battery using a hydrometer. [04]

b) Describe the process involved in servicing an Automatic Transmission. [06]

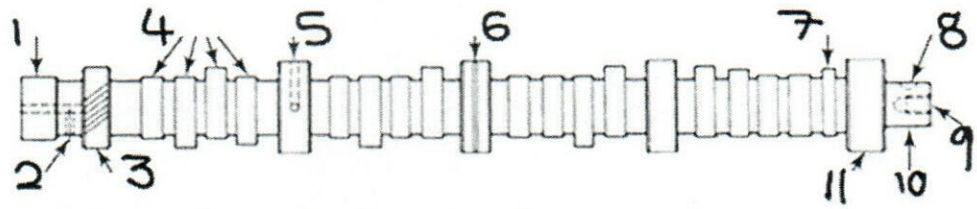
ii) Clutch has an important role to help the driver in controlling transmission gearshift while driving. The clutch function is to disconnect the power from the engine to the transmission so that the gearshift can be done easily. [10]
Explain the process of adjusting the clutch pedal in terms of height adjustment and free play adjustment. Use sketches where necessary.

Total 20

Q5 **i)** a) What are the steps followed to completely disassemble an overhead valve cylinder head for rebuilding? [04]

b) List out and explain the methods used to detect cracks in engine heads and blocks [06]

ii) a) The major function of a camshaft is to open and close valves. The camshaft opens the valve against the force of the valve spring, changing rotary motion into linear motion.
Identify the parts of the camshaft given below [04]



b) A crankshaft service consists of the following procedures. [06]

1. Visual Inspection
2. Measuring the crankshaft
3. Crankshaft grinding
4. Crankshaft Polishing
5. Stress Relieving the crankshaft

Explain in brief the 5 processes listed above

Total [20]

End of the Question Paper

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Faculty of Engineering & Technology
Department of Mechanical and Automotive Engineering
BSc. Hons. (Eng.) in Mechanical Engineering
Semester 6 First Sit - Final Examination 2026
Batch : 6

Module Code: ME3226	**Module Title: Metallurgy for Engineers**
Date: 23 May, 2026	**Duration: 2 hours**
Examiner :	**S. R. Herath**

Instructions to Candidates:

- *This is a closed book examination. No reference materials are allowed.*
- *This paper consists of three (3) questions and 10 pages. Answer all questions.*
- *Write your answers in the provided space in the question paper. If you need more space, you can use the space in the last page of the question paper. Rough sheets will be given.*
- *The marks allocated to each question are listed in the column on the far right. Final mark of the question paper will be calculated out of 100.*
- *Write clearly and legibly. Use a blue or black pen only.*
- *Write your student number on all sheets.*
- *In case if you use additional paper, please write your student number and attach them with your paper.*

Student Number

Q1 **i)** Figure 1 shows the equilibrium phase diagram of Fe-C alloy.

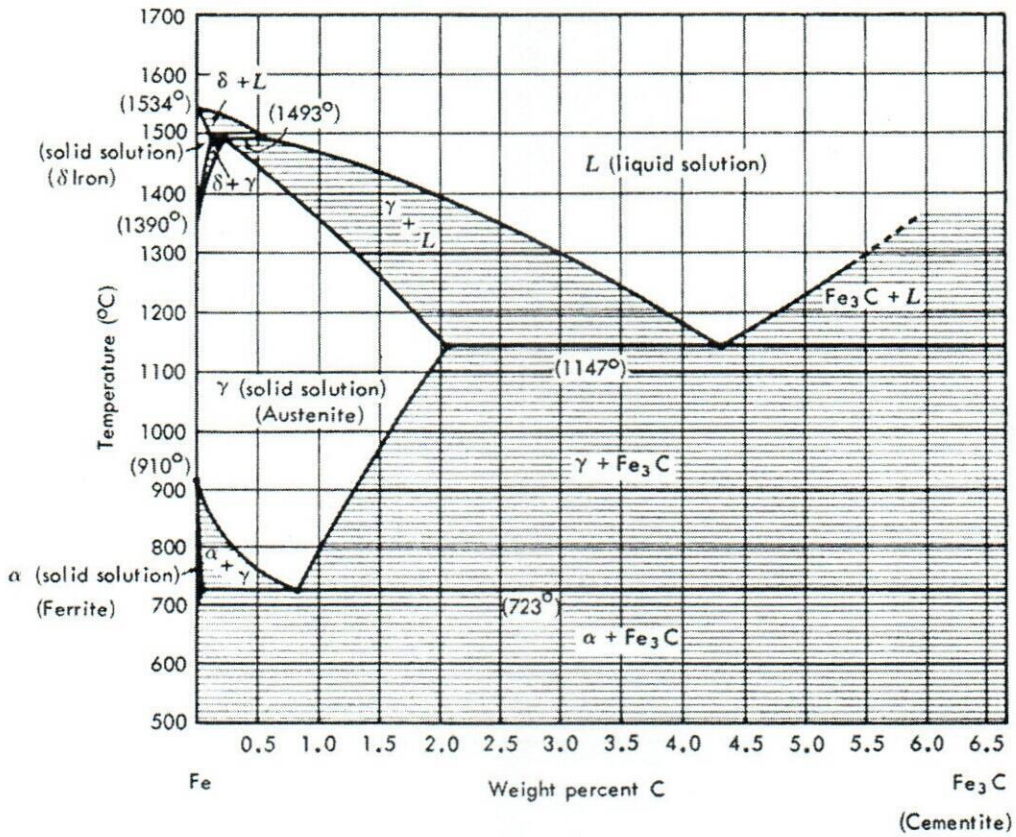


Figure 1

If a 0.2% C plain carbon steel is cooled slowly from the austenite region to room temperature, draw sketches of equilibrium microstructures at 900 ^{0}C, 750 ^{0}C, 724 ^{0}C and 722 ^{0}C. Give the constitution of alloy (the number of phases, weight fraction of each phase and composition of each phase) for each temperature. Take solubility of Carbon of ferrite as 0.02% at eutectoid temperature and eutectoid composition as 0.8 %C. [20]

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ii) Explain briefly the following terms used in heat treatment of steel. [04]

a) Process annealing

b) Austenitizing

c) Normalizing

Student Number [ ]

d) Quenching

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iii) Given in Figure 2 is a TTT diagram for 0.5% C steel. Describe the microstructure present in the steel after each step in the following heat treatments (Give expected fraction of phases and sketch the microstructure for each case).

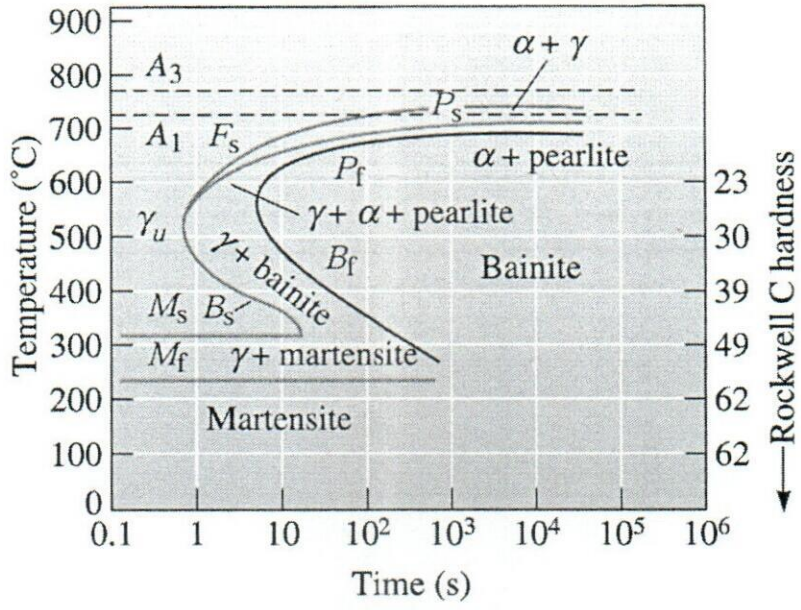


Figure 2

a) Austenitize at 820°C, quench to 650°C and hold for 90 s, and quench to 25°C. [03]

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b) Austenitize at 820°C, quench to 450°C and hold for 90 s, and quench to 25°C [03]

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c) Austenitize at 820°C, and quench to 25°C [03]

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d) Austenitize at 820°C, quench to 720°C and hold for 100 s, and quench to 25°C [03]

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e) Austenitize at 820°C, quench to 720°C and hold for 100 s, quench to 400°C and hold for 500 s, and quench to 25°C [03]

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f) Austenitize at 820°C, quench to 720°C and hold for 100 s, quench to 400°C and hold for 10 s, and quench to 25°C [03]

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g) Austenitize at 820°C, quench to 25°C, heat to 500°C and hold for 10^3 s, and air cool to 25°C [03]

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Total [45]

Student Number

Q2. **i)** What is the difference between Cast iron and steel? [05]

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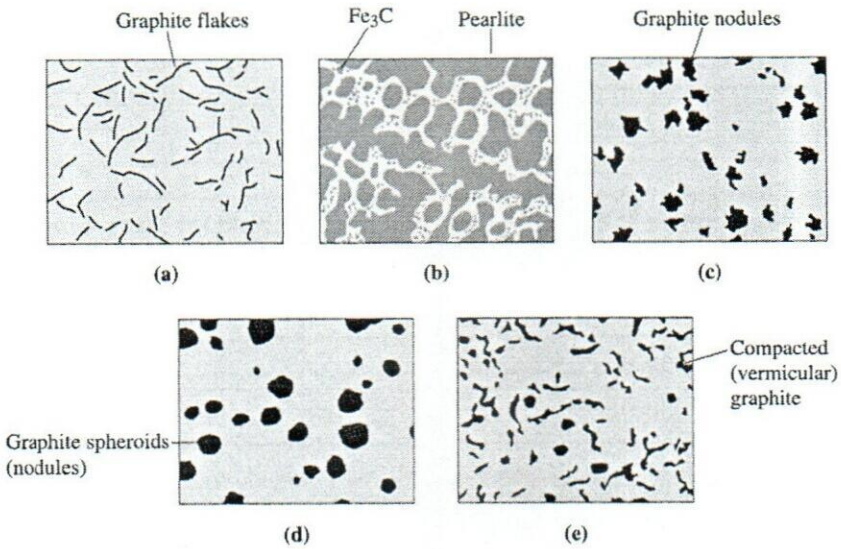


Figure 3

ii) Identify the schematic microstructures of cast iron given in **Figure 3** and explain each of them briefly. [15]

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b) .....
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c) .....
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d) .....
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Student Number

e) .....
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Total [20]

Q3. i) a) What is called 'electrochemical corrosion'? What are the four components of an electrochemical cell? [06]

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b) Describe 'Galvanic attack' and give three different types of galvanic cells. [05]

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Student Number [ ]

c) Several types of metallic coatings including zinc, lead, tin, cadmium, aluminum and nickel are used to protect steel. In which of these cases will the coating provide protection even when the coating is locally disrupted? Explain. [04]

Galvanic series for Q3 i (c)

Anodic	Zn
↓	Aluminum
	Cadmium
	Steel
	Lead
	Tin
Cathodic	Nickel

ii) a) What are the characteristic microstructural features associated with ductile fracture? [05]

Student Number

b) What are the characteristic microstructural features associated with a brittle fracture in a metallic material? [05]

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c) A cylindrical tool steel specimen that is 150 mm long and 6 mm in diameter rotates as a cantilever beam and is to be designed so that fatigue failure never occurs. Assuming that the maximum tensile and compressive stresses are equal, determine the maximum load that can be applied to the end of the beam. (See **Figure 4** for the S-N curve of the material). The maximum stress which occurs at the cantilever beam is given by $\sigma = 32LF/\pi d^3$ where, L and d are the length and diameter of the specimen and F is the end load. [10]

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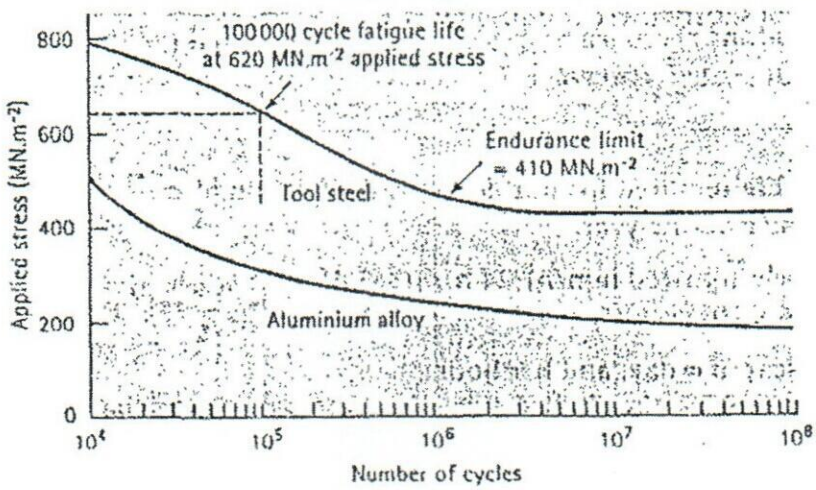


Figure 4

End of the Question Paper

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Faculty of Engineering & Technology

Department of Mechanical & Automotive Engineering

BSc. Hons. (Eng.) in Mechanical Engineering

BSc. Hons. (Eng.) in Automotive Engineering

Semester 6 First Sit - Final Examination 2026

Module Number: ME3323	**Module Name: Machine Design**
Date: 16 May 2026	**Duration: Three Hours**
Examiner 1 **Examiner 2**	**P. D. Sarath Chandra**

Instructions to Candidates:

This is a closed book examination. No reference materials are allowed unless specified.

- *This paper consists of four (04) questions. Answer all questions.*
- *The marks allocated to each question are listed in the column on the far right. Final mark of the question paper will be calculated out of 100.*
- *Use only the provided answer booklet, additional sheets, and graph papers for your answers.*
- *Write clearly and legibly. Use a blue or black pen only.*
- *Write your student number on all sheets.*
- *Start each question on a new page in the answer booklet, answer sheets. Clearly indicate the question number at the top of the page.*
- *If parts of the same question are written discontinuously in non-consecutive sheets, ensure that each part is relevantly labelled with its corresponding question number.*
- *Where appropriate, include clear diagrams or sketches to present your answers effectively.*
- *SI units must be used throughout, except in cases where the use of alternative units is essential and clearly justified.*
- *Supplementary information is given at the end of the question paper.*
- *If you are unsure about the wording of a question, consult the Supervisor or Invigilator, or make reasonable assumptions. Clearly state such assumptions in your answer script.*
- *Marks will be deducted for missing or incorrect measuring units, and failure to adhere to the above instructions.*

Q1 **Figure Q1** illustrates an overhung stepped shaft subjected to a force, P of 1 kN, applied on the centre line of the tommy bar which passes through the shaft front end. The rear end of the shaft is rigidly fixed to a vertical frame. The shaft is made of plain carbon steel with tensile yield strength S_{yt} = 380 N.mm^{-2}. Answer the following questions with a design factor of 2 used where necessary.

i From the given data, what is the shear yield strength according to the maximum shear stress theory and allowable shear stress? 05

ii Illustrate (sketch) the variation of bending moment and torsional moment of the shaft along the shaft's span under the given loading condition. 05

iii What are the maximum values of bending moment (M_b) and torsional moment (M_t)? 10

iv Calculate the bending stress and torsional shear stress at point A on the shaft as a function of shaft diameter 'd'. If point A coincides with the shaft center on the x-z plane, analyze for the bending and torsional stresses at this point. What are the values of each stress? 15

v Illustrate the stresses acting on a stress element at A as shown in the figure, and express these stresses as a function of 'd'. 05

vii Determine the shaft diameter 'd' when applying Maximum Shear Stress Theory. 10

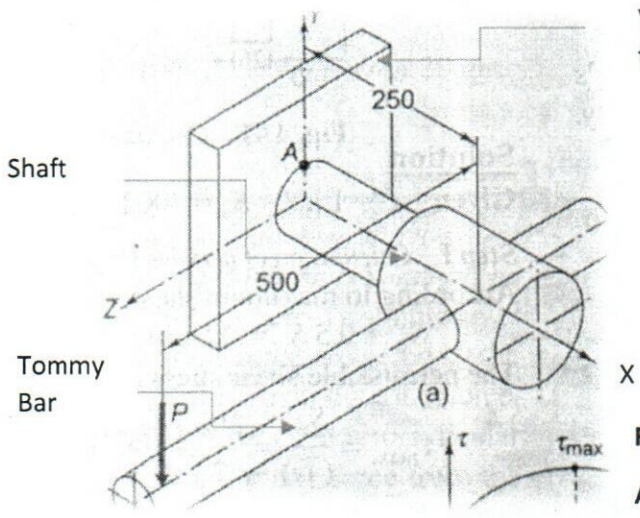


Figure Q1

All dimensions are in mm

Total 50

Q2 i In the analysis of failure theories under a three-dimensional stress state, the evaluation begins with the determination of the **principal stresses**. These principal stresses are obtained as the **eigenvalues of the stress tensor,** which represent the normal stresses acting on mutually orthogonal planes where shear stresses vanish. **20**

The following 3 x 3 matrix provides stresses in $N.mm^{-2}$ at a point of a mechanical component.

$$S = 100 \begin{pmatrix} 1 & 0 & -1 \\ 0 & 1 & 1 \\ -1 & 1 & 2 \end{pmatrix}$$

ii a State the characteristic equation in terms of S (given stress matrx), I (identity matrix) and λ (eigenvalues). 05

b Solve the characteristic equation for three principal stresses and list them. 10

c Using the principal stresses, construct three Mohr's circles. Show clearly how each circle represents a maximum shear stress. 05

d What is the **maximum shear stress** among the three principal shear stresses in a three-dimensional stress state, and what is the **engineering significance** of this value in the design of machine components? 05

iii a Explain the application of the following three theories of failures considering three principal stresses as σ_1, σ_2 and σ_3 and the yield tensile strength as S_{yt} resulted from a uniaxial tensile test conducted under the laboratory conditions. 15

- Maximum Principal Stress (Rankine) Theory
- Maximum Shear Stress (Treca's) Criterion
- Distortion Energy (Von Misses) Criterion

b Using each failure theory referenced in Question (a), and the principal stresses calculated in Question (i) (denoted as $\sigma_1, \sigma_2, \sigma_3$ with $\sigma_1 > \sigma_2 > \sigma_3$), evaluate the safety of the component. Assume the following material properties: 10

- Tensile yield strength: $S_{yt} = 380$ N/mm^2
- Shear yield strength: $S_{ys} = 0.5\, S_{yt}$

Total 50

Q3 i A power transmission shaft supporting two pulleys A and B and mounted between two bearings C_1 and C_2 is shown int the **Figure Q3.** Power is transmitted from pulley A to pulley B. The shaft is made of plain carbon steel, of which S_{ut} = 600 $N.mm^{-2}$ and S_{yt} = 380 $N.mm^{-2}$. The slack and tight side of the belt on pulley B are 30^0 to the vertical. The diameters of the

pulleys and their layout are shown in the figure. Answer the following questions in that given order.

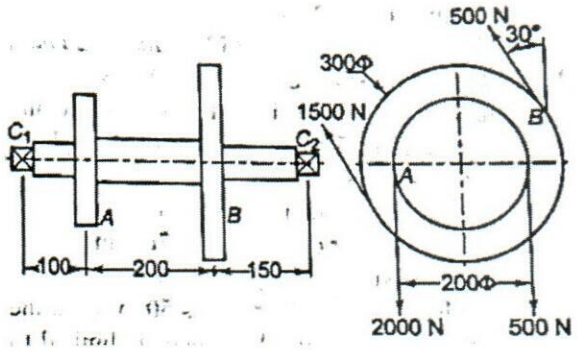


Figure Q3

a Determine the bearing reactions in both the vertical and horizontal planes. Present clearly labelled loading diagrams for each plane. 10

b Construct the bending moment diagram on each plane. Indicate the magnitudes of bending moments at all points of discontinuity. 20

c Combine the results in b) to sketch the resultant bending moment diagram. Record the bending moment values at the discontinuity points. 10

d Draw the torque diagram along the entire span of the shaft. 05

e Identify the critical location on the shaft where failure is most likely to occur, providing justification based on combined stress analysis. 05

f Assuming that the pulleys are keyed to the shaft, determine the required shaft diameter in accordance with the ASME code for shafts. 20

Use the shock and fatigue factors given below:

- Bending: $K_b = 1.5$
- Torsion: $K_t = 1.0$

ASME Code equation is given in conventional notations as

$$\tau_{max} = \frac{16}{\pi d^3}\sqrt{(k_b M_b)^2 + (k_t M_t)^2}$$

Allowable shear stress is decided from the following criteria:

0.18 S_{yt} or 0.30 S_{ut} whichever the lowest. If required, a design code can be considered further.

When a shaft contains **keyways**, the allowable shear stress is typically reduced by approximately **30%** to account for the loss of strength and increased stress concentration introduced by the keyway.

ii a If the shaft diameter is designed based on torsional rigidity, formulate the relationship: 15

$\theta(degrees) = \frac{584 L M_t}{G d^4}$, where L is the length (in mm) of the shaft subjected to the twisting moment M_t (N.mm), G is modulus of rigidity (N.mm^{-2}) and d is the shaft diameter (mm).

The torsion formula for a cylindrical solid shaft, expressed in conventional terms, is given by:

$$\frac{T}{J} = \frac{\tau}{d/2} = \frac{G\theta}{L}$$

b Determine the shaft diameter for question of part i) on the basis of torsional rigidity, if the permissible angle of twist of the shaft between the pulleys is 0.5^0 and the modulus of rigidity is 79,300 N.mm^{-2}. 10

iii Compare the two values resulted in questions i) f) and ii)-b) for the shaft diameter, and state which of the two values is recommended as the safest diameter. Give reasons to justify your answer 05

Total 100

Q4 A V-belt connects an electric motor to a compressor. Belt sectional details are given in **Figure Q4**) and the other required information relevant to the belt drive are givenbelow. Calculate the number of belts required for this application. Your analysis should follow the steps listed from i) to ix).

i Find angles of wrap for driver and driven pulleys. 05

ii Decide the pulley that governs the design and calculate the ratio of tensions. 05

iii Evaluate the area of the cross section of the V-belt. 05

iv Determine the mass of the belt per unit length in correct units. 05

v Determine the belt velocity and centrifugal tensions. 05

	vi	Calculate values for slack and tight side tensions of the belt, and the power that can be transmitted by the belt.	10
	vii	Determine the number of belts required to transmit the required power.	05
	viii	Determine the number of belts required to transmit the required power.	05
	ix	Evaluate the initial tension to be set on the belt based on the calculations above	05
		Total	**50**
Q5.	i	Illustrate design features of the following types of keys and discuss how the specific characteristics of each key serve a distinct purpose in power transmission. Appropriate sketches may help present the answers clearly. Square key Feather key Kennedy key	15
	ii	Prove analytically that a square key made of a ductile material is equally strong in shear and crushing when the material properties are such that the compressive strength is approximately twice the shear strength. [10 marks]	10
	iii	Explain why a Round Key, known as Nordberg Key, which is similar to round pin with a taper of 1:200, and mean diameter generally taken as one-sixth the shaft diameter is considered satisfactory for heavy duty toque transmission.	05
	iv	Determinate analytically the minimum length of key with 20 mm wide when it is to be used on a gear driving shaft with 80 mm diameter designed to operate at a torsional working stress of 75 MPa. Comment on the key length if the standards for keys specify the length of a key should be around 1.5 times the shaft diameter.	10
	v	A cast iron pulley is to be keyed to a 70 mm diameter shaft made of mild steel. The shaft is required to transmit 95 kN at 175 rpm. A flat key of cold finished carbon steel having ultimate strength of 400 $N.mm^{-2}$ is used. The drive is subjected to minor vibration requiring a design factor of 1.75. Assume that the width of the key is one-fourth of the shaft diameter and the depth of the key is 0.7 of the width of the key. Cast iron has $S_u = 1.3\ S_{su}$ and $S_c = S_u$. Determine the length of the key.	10
		Total	**50**

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Faculty of Engineering & Technology
Department of Mechanical & Automotive Engineering
BSc. Hons. (Eng.) in Mechanical Engineering
BSc. Hons. (Eng.) in Automotive Engineering
Semester 6 First Sit - Final Examination 2026
Batch: 06

Module Code: ME3322	**Module Title: Refrigeration & Air Conditioning**
Date: 14th May 2026	**Duration: 03 Hours**
Examiner 1:	**Asiri Manchanayaka**
Examiner 2:	**Sarath Chandra**

Instructions to Candidates:

- *This is a closed book examination. No reference materials are allowed unless specified.*
- *This paper consists of four (4) questions and 11 pages. Answer all questions.*
- *The marks allocated to each question are listed in the column on the far right. Final mark of the question paper will be calculated out of 100.*
- *Use only the provided answer booklet, additional sheets, and graph papers for your answers.*
- *Write clearly and legibly. Use a blue or black pen only.*
- *Write your student number on all sheets.*
- *Start each question on a new page in the answer booklet, answer sheets. Clearly indicate the question number at the top of the page.*
- *If parts of the same question are written discontinuously in non-consecutive sheets, ensure that each part is relevantly labelled with its corresponding question number.*
- *Use the Psychrometric chart and the other data provided for answering questions 03 and 04.*
- *Attach the Psychrometric chart with your answer booklet.*

Q1 **i)** a) "Explain the principle of a thermodynamic heat engine. Outline the main components and their functions in enabling a system to operate as a heat engine. Use appropriate diagrams to support your explanation. [04]

b) Is it possible to completely eliminate heat rejection from a heat engine while maintaining continuous operation? Explain. [04]

c) Is there any contradiction between the Clausius Statement and the Second Law of Thermodynamics? Justify your answer with facts. [04]

ii) The manufacturer of an air conditioner claims a COP of 16 (Btu/h)/W for one of its units. This unit operates on the normal vapor- compression refrigeration cycle and uses refrigerant-22 as the working fluid. This COP claim is for the operating conditions of evaporator saturation with temperature is −5°C and the condenser saturation temperature with 45°C. Selected data for refrigerant 22 are provided in the following table. (1 W = 3.412 Btu/h)

$T\ ^0C$	P_{sat}, kPa	h_f, kJ/kg	h_g, kJ/kg	S_g, kJ/kg.K
-5	421.2	38.76	248.1	0.9344
45	1728	101	261.9	0.8682

a) Sketch typical hardware configuration and T-s diagram for this air conditioner. [03]

b) Determine the heat absorbed by the refrigerant in the evaporator per unit mass of refrigerant-22 in kJ/kg. [03]

c) Determine the work input to the compressor and the heat rejected in the condenser per unit mass of refrigerant-22, in kJ/kg. [04]

iii) A refrigerator that operates on the ideal vapor compression cycle with refrigerant-134a is to maintain the refrigerated space at −10°C, while rejecting heat to the environment at 25°C. Select reasonable pressures for the evaporator and the condenser and explain why you chose those values. [03]

Q2. **i)** a) Draw the schematic diagram of an ammonia absorption refrigeration system and identify its main components. [05]

b) Compare and contrast vapour compression refrigeration systems and vapour absorption refrigeration systems with respect to three clearly defined aspects. [03]

ii) a) In most domestic refrigerators, the capillary tube is placed in thermal contact with the suction line to form a suction-line heat exchanger. Give two reasons for this arrangement. [04]

b) Explain the operation of a thermostatic expansion valve (TXV) with the help of suitable diagrams. [03]

c) Describe why the suction line copper tubing in a refrigeration system is insulated. [02]

iii) a) Draw a schematic diagram of an Air Handling Unit (AHU) indicating the supply air, return air, and fresh air lines, along with all major components. Clearly label each component in the diagram. [05]

b) Write three different methods used to determine when an AHU filter requires replacement. [03]

Q3. i)

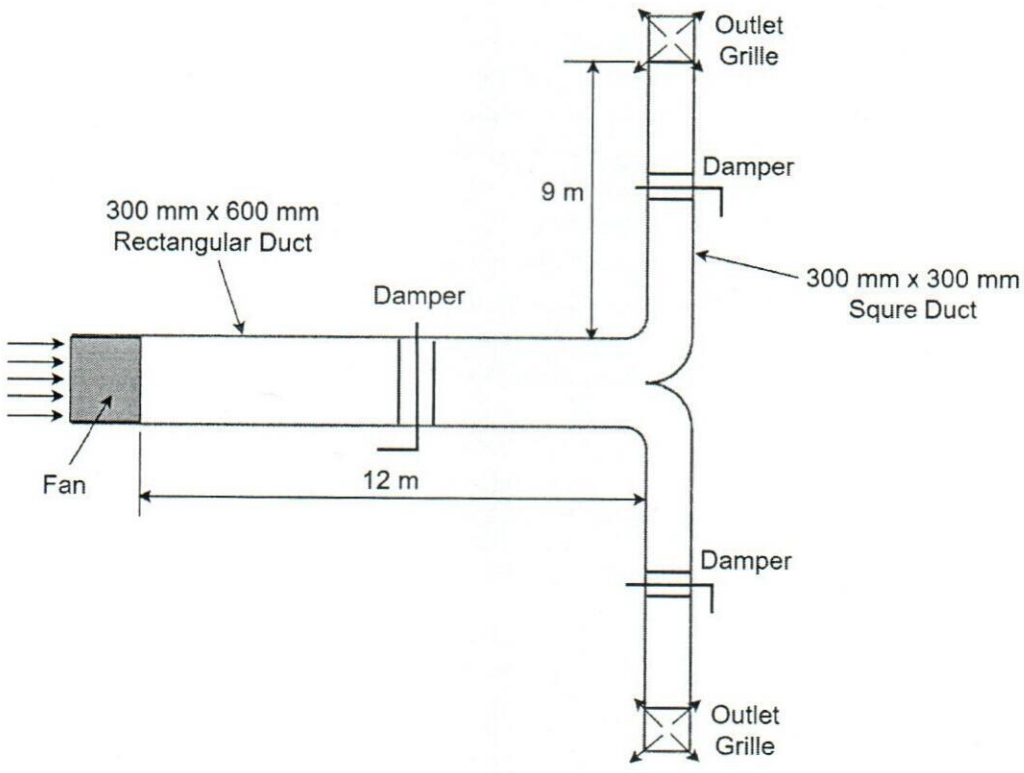


Figure Q3(i)

A ventilation duct system consists of an intake fan, a 12 m long rectangular duct of dimensions 600 mm × 300 mm, a symmetrical wye junction, and a 9 m long square duct of dimensions 300 mm × 300 mm, together with dampers and outlet grilles as shown in Figure Q3(i). If the intake air velocity is 2 m/s, calculate the pressure drop across each duct section and along each airflow path. [18]

ii) Moist air leaving the cooling coil of an air-conditioning system at 14 °C and 100% relative humidity flows at a rate of 40 m^3/min. This air is mixed adiabatically with outdoor air entering at 32 °C and 55% relative humidity at a flow rate of 30 m^3/min. Assuming the mixing process takes place at atmospheric pressure (1 atm), determine the following properties of the mixed air.

a) Specific humidity [04]
b) Relative humidity [02]
c) Dry-bulb temperature [01]

Q4. A factory premises with automated machineries is to be maintained at 27 0C and 60% RH by circulating conditioned air at a rate of 2.0 kg/s. Six machines, each releasing heat at a rate of 1.7 kW, operating inside the premises. 50 fluorescent lamps each releasing 40 W heat are used for lighting the conditioned space. Heat gain through infiltration, walls, roofs and occupancy is estimated to be 'x' kW and 30 kg of water vapour is to be removed every hour from space. 15% fresh air at 36 ^{0}C and 70% RH is supplied to ventilate the conditioned space. Assume that the Air Handling Unit (AHU) consists of a mixing chamber and a cooling coil. Neglect losses in the duct system and in the other fluid dynamics machinery. Assume Apparatus Dew Point (ADP) of the cooling coil is 5 ^{0}C.

i) Sketch the air conditioning process on the psychrometric chart. [10]
ii) Determine 'x', total room latent load and total sensible heat gain through infiltration, walls, roof and occupancy. [08]
iii) Determine the temperature and the relative humidity of the conditioned air entering the conditioned space and the room sensible heat ratio. [04]
iv) Estimate the amount of refrigeration required to provide these conditions. [03]

End of the Question Paper

Data sheet

TABLE A–11

Saturated refrigerant-134a—Temperature table

		Specific volume, m³/kg		*Internal energy,* kJ/kg			*Enthalpy,* kJ/kg			*Entropy,* kJ/kg·K		
Temp., T °C	Sat. press., P_{sat} kPa	Sat. liquid, v_f	Sat. vapor, v_g	Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
−40	51.25	0.0007053	0.36064	−0.036	207.42	207.38	0.00	225.86	225.86	0.00000	0.96869	0.96869
−38	56.86	0.0007082	0.32718	2.472	206.06	208.53	2.512	224.62	227.13	0.01071	0.95516	0.96588
−36	62.95	0.0007111	0.29740	4.987	204.69	209.68	5.032	223.37	228.40	0.02137	0.94182	0.96319
−34	69.56	0.0007141	0.27082	7.509	203.32	210.83	7.559	222.10	229.66	0.03196	0.92867	0.96063
−32	76.71	0.0007171	0.24706	10.04	201.94	211.97	10.09	220.83	230.93	0.04249	0.91569	0.95819
−30	84.43	0.0007201	0.22577	12.58	200.55	213.12	12.64	219.55	232.19	0.05297	0.90289	0.95586
−28	92.76	0.0007232	0.20666	15.12	199.15	214.27	15.19	218.25	233.44	0.06339	0.89024	0.95364
−26	101.73	0.0007264	0.18947	17.67	197.75	215.42	17.75	216.95	234.70	0.07376	0.87776	0.95152
−24	111.37	0.0007296	0.17398	20.23	196.34	216.57	20.31	215.63	235.94	0.08408	0.86542	0.94950
−22	121.72	0.0007328	0.15999	22.80	194.92	217.71	22.89	214.30	237.19	0.09435	0.85323	0.94758
−20	132.82	0.0007361	0.14735	25.37	193.49	218.86	25.47	212.96	238.43	0.10456	0.84119	0.94575
−18	144.69	0.0007394	0.13589	27.96	192.05	220.00	28.07	211.60	239.67	0.11473	0.82927	0.94401
−16	157.38	0.0007428	0.12550	30.55	190.60	221.15	30.67	210.23	240.90	0.12486	0.81749	0.94234
−14	170.93	0.0007463	0.11605	33.15	189.14	222.29	33.28	208.84	242.12	0.13493	0.80583	0.94076
−12	185.37	0.0007498	0.10744	35.76	187.66	223.42	35.90	207.44	243.34	0.14497	0.79429	0.93925
−10	200.74	0.0007533	0.099600	38.38	186.18	224.56	38.53	206.02	244.55	0.15496	0.78286	0.93782
−8	217.08	0.0007570	0.092438	41.01	184.69	225.69	41.17	204.59	245.76	0.16491	0.77154	0.93645
−6	234.44	0.0007607	0.085888	43.64	183.18	226.82	43.82	203.14	246.95	0.17482	0.76033	0.93514
−4	252.85	0.0007644	0.079889	46.29	181.66	227.94	46.48	201.66	248.14	0.18469	0.74921	0.93390
−2	272.36	0.0007683	0.074388	48.94	180.12	229.07	49.15	200.17	249.33	0.19452	0.73819	0.93271
0	293.01	0.0007722	0.069335	51.61	178.58	230.18	51.83	198.67	250.50	0.20432	0.72726	0.93158
2	314.84	0.0007761	0.064690	54.28	177.01	231.30	54.53	197.14	251.66	0.21408	0.71641	0.93050
4	337.90	0.0007802	0.060412	56.97	175.44	232.40	57.23	195.58	252.82	0.22381	0.70565	0.92946
6	362.23	0.0007843	0.056469	59.66	173.84	233.51	59.95	194.01	253.96	0.23351	0.69496	0.92847
8	387.88	0.0007886	0.052829	62.37	172.23	234.60	62.68	192.42	255.09	0.24318	0.68435	0.92752
10	414.89	0.0007929	0.049466	65.09	170.61	235.69	65.42	190.80	256.22	0.25282	0.67380	0.92661
12	443.31	0.0007973	0.046354	67.82	168.96	236.78	68.17	189.16	257.33	0.26243	0.66331	0.92574
14	473.19	0.0008018	0.043471	70.56	167.30	237.86	70.94	187.49	258.43	0.27201	0.65289	0.92490
16	504.58	0.0008064	0.040798	73.31	165.62	238.93	73.72	185.80	259.51	0.28157	0.64252	0.92409
18	537.52	0.0008112	0.038317	76.07	163.92	239.99	76.51	184.08	260.59	0.29111	0.63219	0.92330
20	572.07	0.0008160	0.036012	78.85	162.19	241.04	79.32	182.33	261.64	0.30062	0.62192	0.92254
22	608.27	0.0008209	0.033867	81.64	160.45	242.09	82.14	180.55	262.69	0.31012	0.61168	0.92180
24	646.18	0.0008260	0.031869	84.44	158.68	243.13	84.98	178.74	263.72	0.31959	0.60148	0.92107
26	685.84	0.0008312	0.030008	87.26	156.89	244.15	87.83	176.90	264.73	0.32905	0.59131	0.92036
28	727.31	0.0008366	0.028271	90.09	155.08	245.17	90.70	175.03	265.73	0.33849	0.58117	0.91967
30	770.64	0.0008421	0.026648	92.93	153.24	246.17	93.58	173.13	266.71	0.34792	0.57105	0.91897
32	815.89	0.0008477	0.025131	95.79	151.37	247.17	96.49	171.19	267.67	0.35734	0.56095	0.91829
34	863.11	0.0008535	0.023712	98.67	149.48	248.15	99.41	169.21	268.61	0.36675	0.55086	0.91760
36	912.35	0.0008595	0.022383	101.56	147.55	249.11	102.34	167.19	269.53	0.37615	0.54077	0.91692
38	963.68	0.0008657	0.021137	104.47	145.60	250.07	105.30	165.13	270.44	0.38554	0.53068	0.91622
40	1017.1	0.0008720	0.019968	107.39	143.61	251.00	108.28	163.03	271.31	0.39493	0.52059	0.91552
42	1072.8	0.0008786	0.018870	110.34	141.59	251.92	111.28	160.89	272.17	0.40432	0.51048	0.91480
44	1130.7	0.0008854	0.017837	113.30	139.53	252.83	114.30	158.70	273.00	0.41371	0.50036	0.91407

TABLE A–11

Saturated refrigerant-134a—Temperature table *(Concluded)*

		Specific volume, m^3/kg		*Internal energy,* kJ/kg			*Enthalpy,* kJ/kg			*Entropy,* kJ/kg·K		
Temp., T °C	Sat. press., P_{sat} kPa	Sat. liquid, v_f	Sat. vapor, v_g	Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
46	1191.0	0.0008924	0.016866	116.28	137.43	253.71	117.34	156.46	273.80	0.42311	0.49020	0.91331
48	1253.6	0.0008997	0.015951	119.28	135.30	254.58	120.41	154.17	274.57	0.43251	0.48001	0.91252
52	1386.2	0.0009151	0.014276	125.35	130.89	256.24	126.62	149.41	276.03	0.45136	0.45948	0.91084
56	1529.1	0.0009317	0.012782	131.52	126.29	257.81	132.94	144.41	277.35	0.47028	0.43870	0.90898
60	1682.8	0.0009498	0.011434	137.79	121.45	259.23	139.38	139.09	278.47	0.48930	0.41746	0.90676
65	1891.0	0.0009751	0.009959	145.80	115.06	260.86	147.64	132.05	279.69	0.51330	0.39048	0.90379
70	2118.2	0.0010037	0.008650	154.03	108.17	262.20	156.15	124.37	280.52	0.53763	0.36239	0.90002
75	2365.8	0.0010373	0.007486	162.55	100.62	263.17	165.01	115.87	280.88	0.56252	0.33279	0.89531
80	2635.3	0.0010774	0.006439	171.43	92.22	263.66	174.27	106.35	280.63	0.58812	0.30113	0.88925
85	2928.2	0.0011273	0.005484	180.81	82.64	263.45	184.11	95.39	279.51	0.61487	0.26632	0.88120
90	3246.9	0.0011938	0.004591	190.94	71.19	262.13	194.82	82.22	277.04	0.64354	0.22638	0.86991
95	3594.1	0.0012945	0.003713	202.49	56.25	258.73	207.14	64.94	272.08	0.67605	0.17638	0.85243
100	3975.1	0.0015269	0.002657	218.73	29.72	248.46	224.80	34.22	259.02	0.72224	0.09169	0.81393

Source of Data: Tables A–11 through A–13 are generated using the Engineering Equation Solver (EES) software developed by S. A. Klein and F. L. Alvarado. The routine used in calculations is the R134a, which is based on the fundamental equation of state developed by R. Tillner–Roth and H.D. Baehr, "An International Standard Formulation for the Thermodynamic Properties of 1,1,1,2-Tetrafluoroethane (HFC-134a) for temperatures from 170 K to 455 K and pressures up to 70 MPa," *J. Phys. Chem, Ref. Data,* Vol. 23, No. 5, 1994. The enthalpy and entropy values of saturated liquid are set to zero at −40°C (and −40°F).

TABLE A–12

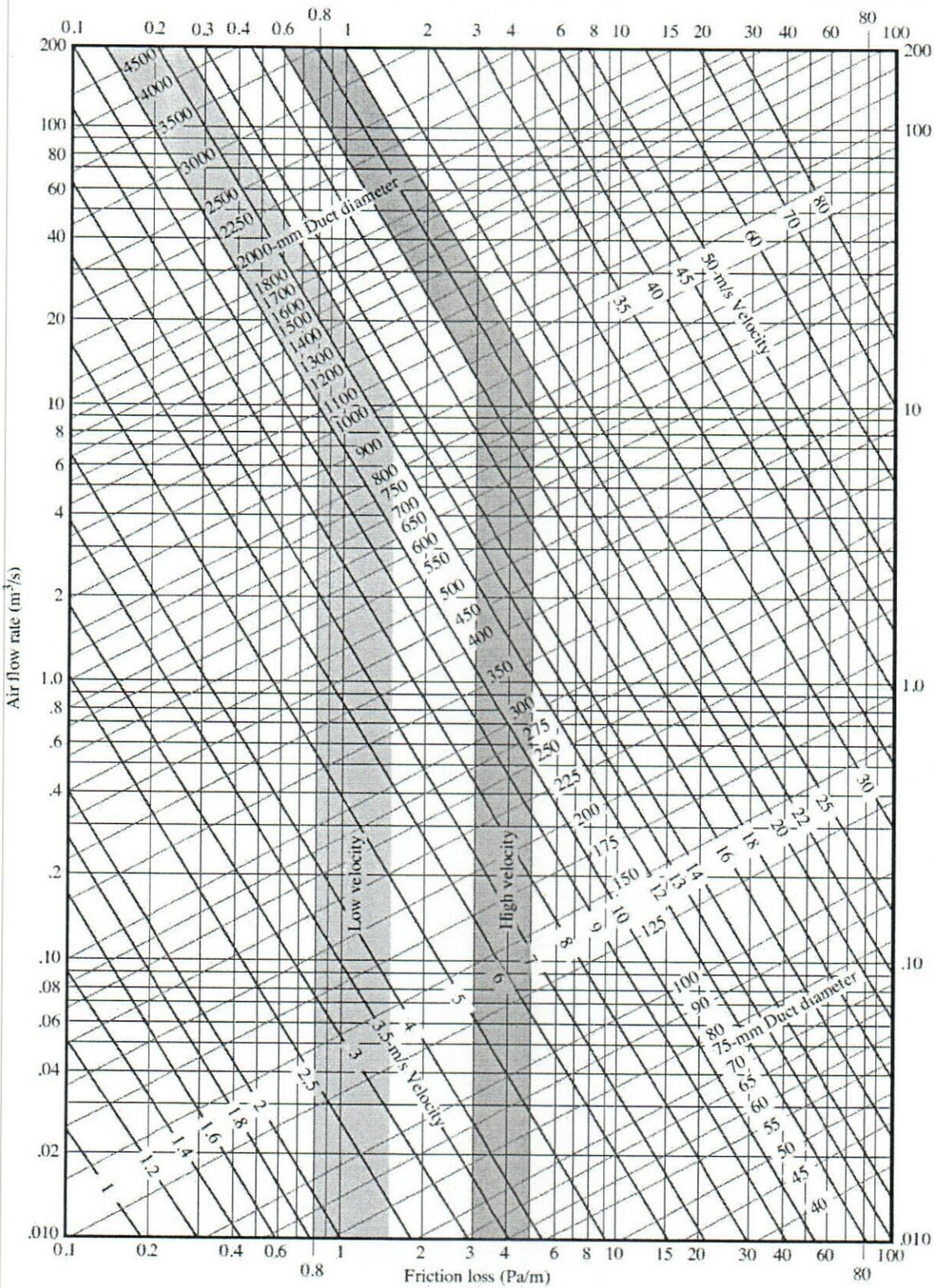
Saturated refrigerant-134a—Pressure table

		Specific volume, m^3/kg		*Internal energy,* kJ/kg			*Enthalpy,* kJ/kg			*Entropy,* kJ/kg·K		
Press., P kPa	Sat. temp., T_{sat} °C	Sat. liquid, v_f	Sat. vapor, v_g	Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
60	−36.95	0.0007097	0.31108	3.795	205.34	209.13	3.837	223.96	227.80	0.01633	0.94812	0.96445
70	−33.87	0.0007143	0.26921	7.672	203.23	210.90	7.722	222.02	229.74	0.03264	0.92783	0.96047
80	−31.13	0.0007184	0.23749	11.14	201.33	212.48	11.20	220.27	231.47	0.04707	0.91009	0.95716
90	−28.65	0.0007222	0.21261	14.30	199.60	213.90	14.36	218.67	233.04	0.06003	0.89431	0.95434
100	−26.37	0.0007258	0.19255	17.19	198.01	215.21	17.27	217.19	234.46	0.07182	0.88008	0.95191
120	−22.32	0.0007323	0.16216	22.38	195.15	217.53	22.47	214.52	236.99	0.09269	0.85520	0.94789
140	−18.77	0.0007381	0.14020	26.96	192.60	219.56	27.06	212.13	239.19	0.11080	0.83387	0.94467
160	−15.60	0.0007435	0.12355	31.06	190.31	221.37	31.18	209.96	241.14	0.12686	0.81517	0.94202
180	−12.73	0.0007485	0.11049	34.81	188.20	223.01	34.94	207.95	242.90	0.14131	0.79848	0.93979
200	−10.09	0.0007532	0.099951	38.26	186.25	224.51	38.41	206.09	244.50	0.15449	0.78339	0.93788
240	−5.38	0.0007618	0.083983	44.46	182.71	227.17	44.64	202.68	247.32	0.17786	0.75689	0.93475
280	−1.25	0.0007697	0.072434	49.95	179.54	229.49	50.16	199.61	249.77	0.19822	0.73406	0.93228
320	2.46	0.0007771	0.063681	54.90	176.65	231.55	55.14	196.78	251.93	0.21631	0.71395	0.93026
360	5.82	0.0007840	0.056809	59.42	173.99	233.41	59.70	194.15	253.86	0.23265	0.69591	0.92856
400	8.91	0.0007905	0.051266	63.61	171.49	235.10	63.92	191.68	255.61	0.24757	0.67954	0.92711
450	12.46	0.0007983	0.045677	68.44	168.58	237.03	68.80	188.78	257.58	0.26462	0.66093	0.92555
500	15.71	0.0008058	0.041168	72.92	165.86	238.77	73.32	186.04	259.36	0.28021	0.64399	0.92420
550	18.73	0.0008129	0.037452	77.09	163.29	240.38	77.54	183.44	260.98	0.29460	0.62842	0.92302
600	21.55	0.0008198	0.034335	81.01	160.84	241.86	81.50	180.95	262.46	0.30799	0.61398	0.92196
650	24.20	0.0008265	0.031680	84.72	158.51	243.23	85.26	178.56	263.82	0.32052	0.60048	0.92100
700	26.69	0.0008331	0.029392	88.24	156.27	244.51	88.82	176.26	265.08	0.33232	0.58780	0.92012
750	29.06	0.0008395	0.027398	91.59	154.11	245.70	92.22	174.03	266.25	0.34348	0.57582	0.91930
800	31.31	0.0008457	0.025645	94.80	152.02	246.82	95.48	171.86	267.34	0.35408	0.56445	0.91853
850	33.45	0.0008519	0.024091	97.88	150.00	247.88	98.61	169.75	268.36	0.36417	0.55362	0.91779
900	35.51	0.0008580	0.022703	100.84	148.03	248.88	101.62	167.69	269.31	0.37383	0.54326	0.91709
950	37.48	0.0008640	0.021456	103.70	146.11	249.82	104.52	165.68	270.20	0.38307	0.53333	0.91641
1000	39.37	0.0008700	0.020329	106.47	144.24	250.71	107.34	163.70	271.04	0.39196	0.52378	0.91574
1200	46.29	0.0008935	0.016728	116.72	137.12	253.84	117.79	156.12	273.92	0.42449	0.48870	0.91320
1400	52.40	0.0009167	0.014119	125.96	130.44	256.40	127.25	148.92	276.17	0.45325	0.45742	0.91067
1600	57.88	0.0009400	0.012134	134.45	124.05	258.50	135.96	141.96	277.92	0.47921	0.42881	0.90802
1800	62.87	0.0009639	0.010568	142.36	117.85	260.21	144.09	135.14	279.23	0.50304	0.40213	0.90517
2000	67.45	0.0009887	0.009297	149.81	111.75	261.56	151.78	128.36	280.15	0.52519	0.37684	0.90204
2500	77.54	0.0010567	0.006941	167.02	96.47	263.49	169.66	111.18	280.84	0.57542	0.31701	0.89243
3000	86.16	0.0011410	0.005272	183.09	80.17	263.26	186.51	92.57	279.08	0.62133	0.25759	0.87893

TABLE A–13

Superheated refrigerant-134a

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
	$P = 0.06$ MPa ($T_{sat} = -36.95$°C)				$P = 0.10$ MPa ($T_{sat} = -26.37$°C)				$P = 0.14$ MPa ($T_{sat} = -18.77$°C)			
Sat.	0.31108	209.13	227.80	0.9645	0.19255	215.21	234.46	0.9519	0.14020	219.56	239.19	0.9447
−20	0.33608	220.62	240.78	1.0175	0.19841	219.68	239.52	0.9721				
−10	0.35048	227.57	248.60	1.0478	0.20743	226.77	247.51	1.0031	0.14605	225.93	246.37	0.9724
0	0.36476	234.67	256.56	1.0775	0.21630	233.97	255.60	1.0333	0.15263	233.25	254.61	1.0032
10	0.37893	241.94	264.68	1.1067	0.22506	241.32	263.82	1.0628	0.15908	240.68	262.95	1.0331
20	0.39302	249.37	272.95	1.1354	0.23373	248.81	272.18	1.0919	0.16544	248.24	271.40	1.0625
30	0.40705	256.97	281.39	1.1637	0.24233	256.46	280.69	1.1204	0.17172	255.95	279.99	1.0913
40	0.42102	264.73	289.99	1.1916	0.25088	264.27	289.36	1.1485	0.17794	263.80	288.72	1.1196
50	0.43495	272.66	298.75	1.2192	0.25937	272.24	298.17	1.1762	0.18412	271.81	297.59	1.1475
60	0.44883	280.75	307.68	1.2464	0.26783	280.36	307.15	1.2036	0.19025	279.97	306.61	1.1750
70	0.46269	289.01	316.77	1.2732	0.27626	288.65	316.28	1.2306	0.19635	288.29	315.78	1.2021
80	0.47651	297.43	326.02	1.2998	0.28465	297.10	325.57	1.2573	0.20242	296.77	325.11	1.2289
90	0.49032	306.02	335.43	1.3261	0.29303	305.71	335.01	1.2836	0.20847	305.40	334.59	1.2554
100	0.50410	314.76	345.01	1.3521	0.30138	314.48	344.61	1.3097	0.21449	314.19	344.22	1.2815
	$P = 0.18$ MPa ($T_{sat} = -12.73$°C)				$P = 0.20$ MPa ($T_{sat} = -10.09$°C)				$P = 0.24$ MPa ($T_{sat} = -5.38$°C)			
Sat.	0.11049	223.01	242.90	0.9398	0.09995	224.51	244.50	0.9379	0.08398	227.17	247.32	0.9348
−10	0.11189	225.04	245.18	0.9485	0.09991	224.57	244.56	0.9381				
0	0.11722	232.49	253.59	0.9799	0.10481	232.11	253.07	0.9699	0.08617	231.30	251.98	0.9520
10	0.12240	240.02	262.05	1.0103	0.10955	239.69	261.60	1.0005	0.09026	239.00	260.66	0.9832
20	0.12748	247.66	270.60	1.0400	0.11418	247.36	270.20	1.0304	0.09423	246.76	269.38	1.0134
30	0.13248	255.43	279.27	1.0691	0.11874	255.16	278.91	1.0596	0.09812	254.63	278.17	1.0429
40	0.13741	263.33	288.07	1.0976	0.12322	263.09	287.74	1.0882	0.10193	262.61	287.07	1.0718
50	0.14230	271.38	297.00	1.1257	0.12766	271.16	296.70	1.1164	0.10570	270.73	296.09	1.1002
60	0.14715	279.58	306.07	1.1533	0.13206	279.38	305.79	1.1441	0.10942	278.98	305.24	1.1281
70	0.15196	287.93	315.28	1.1806	0.13641	287.75	315.03	1.1714	0.11310	287.38	314.53	1.1555
80	0.15673	296.43	324.65	1.2075	0.14074	296.27	324.41	1.1984	0.11675	295.93	323.95	1.1826
90	0.16149	305.09	334.16	1.2340	0.14504	304.93	333.94	1.2250	0.12038	304.62	333.51	1.2093
100	0.16622	313.90	343.82	1.2603	0.14933	313.75	343.62	1.2513	0.12398	313.46	343.22	1.2356
	$P = 0.28$ MPa ($T_{sat} = -1.25$°C)				$P = 0.32$ MPa ($T_{sat} = 2.46$°C)				$P = 0.40$ MPa ($T_{sat} = 8.91$°C)			
Sat.	0.07243	229.49	249.77	0.9323	0.06368	231.55	251.93	0.9303	0.051266	235.10	255.61	0.9271
0	0.07282	230.46	250.85	0.9362								
10	0.07646	238.29	259.70	0.9681	0.06609	237.56	258.70	0.9545	0.051506	235.99	256.59	0.9306
20	0.07997	246.15	268.54	0.9987	0.06925	245.51	267.67	0.9856	0.054213	244.19	265.88	0.9628
30	0.08338	254.08	277.42	1.0285	0.07231	253.52	276.66	1.0158	0.056796	252.37	275.09	0.9937
40	0.08672	262.12	286.40	1.0577	0.07530	261.62	285.72	1.0452	0.059292	260.60	284.32	1.0237
50	0.09000	270.28	295.48	1.0862	0.07823	269.83	294.87	1.0739	0.061724	268.92	293.61	1.0529
60	0.09324	278.58	304.69	1.1143	0.08111	278.17	304.12	1.1022	0.064104	277.34	302.98	1.0814
70	0.09644	287.01	314.01	1.1419	0.08395	286.64	313.50	1.1299	0.066443	285.88	312.45	1.1095
80	0.09961	295.59	323.48	1.1690	0.08675	295.24	323.00	1.1572	0.068747	294.54	322.04	1.1370
90	0.10275	304.30	333.07	1.1958	0.08953	303.99	332.64	1.1841	0.071023	303.34	331.75	1.1641
100	0.10587	313.17	342.81	1.2223	0.09229	312.87	342.41	1.2106	0.073274	312.28	341.59	1.1908
110	0.10897	322.18	352.69	1.2484	0.09503	321.91	352.31	1.2368	0.075504	321.35	351.55	1.2172
120	0.11205	331.34	362.72	1.2742	0.09775	331.08	362.36	1.2627	0.077717	330.56	361.65	1.2432
130	0.11512	340.65	372.88	1.2998	0.10045	340.41	372.55	1.2883	0.079913	339.92	371.89	1.2689
140	0.11818	350.11	383.20	1.3251	0.10314	349.88	382.89	1.3136	0.082096	349.42	382.26	1.2943



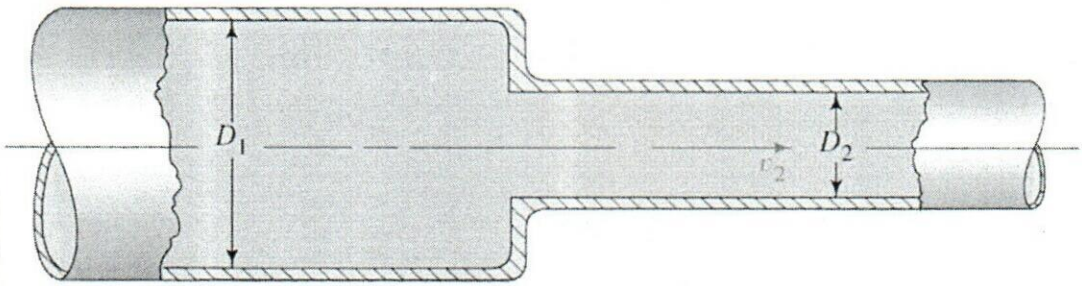
Friction loss in ducts—SI units. *(Source: ASHRAE Handbook)*

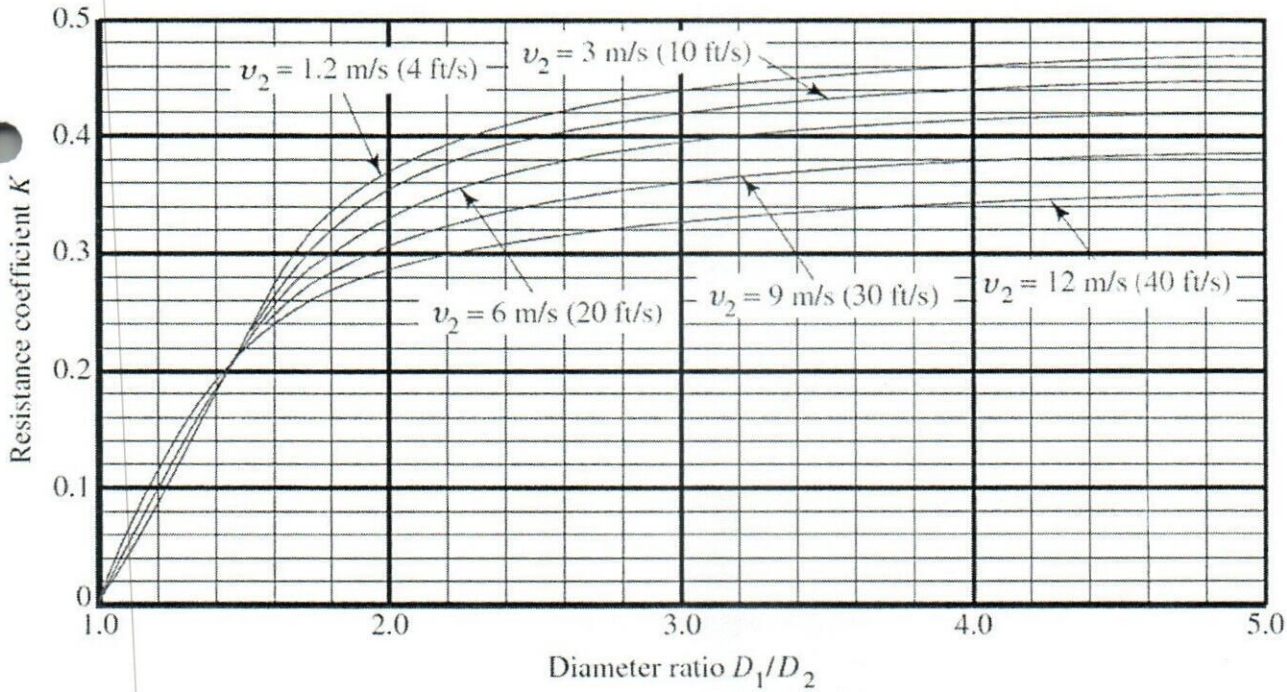
Circular equivalent diameters of rectangular ducts

Side b (in)	Side a (in)												
	6	8	10	12	14	16	18	20	22	24	26	28	30
6	6.6												
8	7.6	8.7											
10	8.4	9.8	10.9										
12	9.1	10.7	12.0	13.1									
14	9.8	11.5	12.9	14.2	15.3								
16	10.4	12.2	13.7	15.1	16.4	17.5							
18	11.0	12.9	14.5	16.0	17.3	18.5	19.7						
20	11.5	13.5	15.2	16.8	18.2	19.5	20.7	21.9					
22	12.0	14.1	15.9	17.6	19.1	20.4	21.7	22.9	24.0				
24	12.4	14.6	16.5	18.3	19.9	21.3	22.7	23.9	25.1	26.2			
26	12.8	15.1	17.1	19.0	20.6	22.1	23.5	24.9	26.1	27.3	28.4		
28	13.2	15.6	17.7	19.6	21.3	22.9	24.4	25.8	27.1	28.3	29.5	30.6	
30	13.6	16.1	18.3	20.7	22.0	23.7	25.2	26.6	28.0	29.3	30.5	31.7	32.8

Examples of loss factors for duct fittings

	Dynamic Loss Coefficient C					
	90° elbows					
	Smooth, round	0.22				
	5-piece, round	0.33				
	4-piece, round	0.37				
	3-piece, round	0.42				
	Mitered, round	1.20				
	Smooth, rectangular	0.18				
	Tee, branch	1.00				
	Tee, flow through main	0.10				
	Symmetrical wye	0.30				
Damper Position	0° (wide open)	10°	20°	30°	40°	50°
C	0.20	0.52	1.50	4.5	11.0	29
Outlet grille: Assume total pressure drop through grille is 0.06 inH_2O (15 Pa).						
Intake louvers: Assume total pressure drop across louver is 0.07 inH_2O (17 Pa).						





Resistance coefficient for a sudden contraction

Circular Equivalent Diameter for a square duct (D_e):

$$D_e = \frac{1.3(ab)^{\frac{5}{8}}}{(a+b)^{\frac{1}{4}}}$$

Dynamic Loss for a duct fitting (H_L):

$$H_L = C(H_v)$$

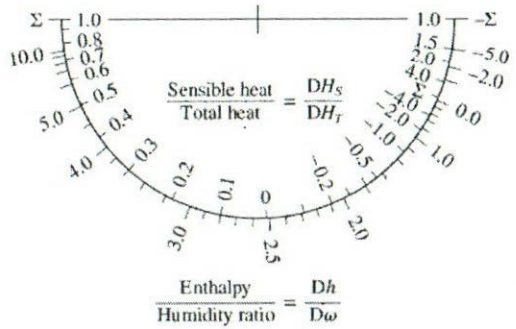
Velocity Pressure (H_v):

$$H_v = \left(\frac{v}{1.289}\right)^2 Pa$$

ASHRAE Psychrometric Chart No. 1
Normal Temperature
Barometric Pressure: 101.325 kPa

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CINEC CAMPUS
Beyond A Graduate

Faculty of Engineering & Technology

Department of Mechanical & Automotive Engineering

BSc Hons (Eng) Batch 6

Semester 6 First Sit – End-Semester Examination 2026

Common Question Paper For all Specializations in BSc (Honours) in Engineering Degree

Module Code	:	FE 3321
Module Title	:	Management for Engineers
Date	:	11 May 2026
Examiner	:	Eng. Asantha Sumanarathna
Time Allowed :	:	3 hours

Instructions to Candidates:

- This is a closed book examination.
- This paper consists of six (06) questions. Answer all six questions.
- Use only the answers booklet, additional papers and graph paper for your answers.
- Write clearly and legibly with a blue or black pen.
- Write your name and student registration number on all sheets.
- Answers to different parts of the same question (other than any graph sheets used) should not be scattered.
- Marks will be deducted for missing or incorrect measuring units.
- You are advised to make a clear diagram for each question, where appropriate. This will help you to present an answer clearly.
- If you have any doubt regarding the interpretation of the wording of a question, make your own assumption(s) and clearly state such assumption(s) along with the answer.

			Marks allocated
Q1			
	i	Discuss the evolution of **management thoughts** from the Classical approach to Modern management theories. Explain how these theories remain relevant to contemporary engineering practice.	5
	ii	Critically evaluate the contributions of key management thinkers, such as Frederick Winslow Taylor, Henri Fayol, and Elton Mayo, and assess their significance in solving present-day engineering management challenges	6
	Iii	Engineers require management knowledge in addition to technical competence. Using the historical development of management theories as a basis, discuss why management principles are important for engineers in planning, organizing, leading, and controlling engineering activities	6
Q2			
	i	Examine the communication process and analyze the significance of effective communication in engineering management. Support your discussion with practical examples drawn from engineering practice.	5
	ii	Critically evaluate barriers to communication in engineering organizations and propose suitable strategies to overcome them to improve project performance and team coordination.	6
	iii	Effective communication is essential for engineering success. Discuss the role of verbal, non-verbal, written, and digital communication in engineering decision-making, leadership, and project management.	6
Q3			
	i	Discuss the phases of the project life cycle and critically evaluate their importance in the successful management of engineering projects.	5
	ii	Project management involves balancing scope, time, cost, and quality. Critically examine how these constraints influence the performance and success of engineering projects.	6
	iii	Discuss the role of project planning, scheduling, risk management, and monitoring and control in achieving successful outcomes in engineering projects.	6
Q4			
	i	Discuss the process of **risk analysis** in engineering projects and explain how an effective risk mitigation plan contributes to project success.	5
	ii	Critically evaluate the identification, assessment, and prioritization of risks in engineering projects, and discuss suitable mitigation strategies for managing those risks.	6

iii Risk management is essential in engineering project planning and execution. Discuss how risk analysis and risk mitigation planning can reduce uncertainty, improve decision-making, and enhance project performance. **6**

Q5

i Discuss the stages of product development and explain how **marketing** contributes to the successful commercialization of engineering products. **5**

ii Critically evaluate the relationship between product development, market research, and customer needs in achieving competitive advantage for engineering organizations. **6**

iii Discuss the role of product development and marketing strategies in transforming ideas into successful products. **5**

Q6

i Differentiate between the roles of a manager and a leader. Discuss why both are essential in engineering project management with appropriate examples. **5**

ii Critically evaluate the differences between authority and power in engineering organizations. Explain how each influences team performance and decision-making. **6**

iii Distinguish between management and leadership roles and analyze their respective importance in engineering project management with suitable illustrations. **5**

END

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CINEC CAMPUS
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Faculty of Engineering & Technology
Department of Mechanical & Automotive engineering
BSc. Hons. (Eng.) in Engineering
Semester 2 First Sit - Final Examination 2026
Batch :8

Module Code: ME1324	**Module Title: Workshop Practice**
Date: 30 April 2026	**Duration: 3hr**
Final Examination	

Instructions to Candidates:

- *This is a closed book examination. No reference materials are allowed unless specified.*
- *This paper consists of four (4) questions and 5 pages.* ***Answer all questions.***
- *The marks allocated to each question are listed in the column on the far right. Final mark of the question paper will be calculated out of 100.*
- *Use only the provided answer booklet, additional sheets, and graph papers for your answers.*
- *Write clearly and legibly. Use a blue or black pen only.*
- *Write your student number on all sheets.*
- *Start each question on a new page in the answer booklet, answer sheets. Clearly indicate the question number at the top of the page.*
- *If parts of the same question are written discontinuously in non-consecutive sheets, ensure that each part is relevantly labelled with its corresponding question number.*
- *any data which is not given assume*

Q1	i)	Discuss the application of cutting fluids in metal cutting operations.	5 Marks
	ii)	Explain the formation of a built-up edge (BUE) during metal cutting operations. Discuss the conditions that promote BUE formation and analyze its effects on tool wear, surface finish, and cutting forces. Also, explain how BUE can be minimized in practical machining processes.	6 Marks
	iii)	In an orthogonal cutting operation, the following data are given: • Uncut chip thickness, $t_1 = 0.25$ mm • Chip thickness, $t_2 = 0.80$ mm • Rake angle, $\alpha = 15°$ • Width of cut, $b = 5$ mm • Shear strength of the work material $\tau_s = 420$ MPa • Cutting velocity, $V = 1.5$ m/s Determine the Followings (a) Shear angle ϕ (b) Friction angle β (c) Shear force F_s (d) Cutting force F_c (e) Percentage of energy spent in shear and friction	14 Marks

Q2	i)	Sketch the electric arc furnace and name the components.	5 Marks
	ii)	A manufacturing company needs to select a suitable casting process for producing a batch of precision mechanical components made of aluminium alloy. The components have thin walls, complex geometry, and require a good surface finish with minimal machining. List and explain the key factors that should be considered when selecting the most appropriate casting method for this application.	6 Marks
	iii)	In a sand-casting process, a sprue of 40 cm height feeds molten metal into a runner system. The sprue base area is 3 cm^2, and the molten metal flows into a mold cavity through a runner of cross-sectional area 1.5 cm^2. The total mold cavity volume is 12,000 cm^3. Assuming ideal flow conditions (no losses) and that the flow is controlled at the runner: Calculate: (a) The velocity of molten metal at the runner (b) The volumetric flow rate (c) The total mold filling time	14 Marks

Q3	i)	Carbide tips are often welded or mechanically clamped onto a steel shank in cutting tools. Explain why this combination is preferred instead of manufacturing the entire tool from either carbide or steel.	5 Marks
	ii)	Explain how temperature affects tool wear mechanisms in cutting tools. In your answer, discuss the influence of temperature on: • Tool material properties • Wear mechanisms such as adhesion, abrasion, and diffusion • Tool life and performance	6 Marks
	iii)	In a production turning operation, a cylindrical workpiece of 150 mm diameter and 400 mm length is being machined using a feed of 0.25 mm/rev. It is observed that: • At a cutting speed of 3.2 m/s, the tool must be changed after producing 6 workpieces. • At a cutting speed of 2.1 m/s, the tool can produce 30 workpieces before requiring replacement. Assume each workpiece requires constant machining time. Determine the Taylor tool life equation of the form: $$VT^n = C$$ where $V$is cutting speed, $T$is tool life, and $n, C$are constants.	14 Marks

Q4	i)	Explain the differences between a three-jaw chuck and a four-jaw chuck used in a lathe machine.	5 Marks
	ii)	In a turning operation, a cylindrical workpiece of 90 mm diameter is to be reduced to 78 mm diameter. The machining is planned to use: • Two rough cuts, each depth of cut of 2.5mm (radial). • One finishing cut with depth 1mm (radial). The operating conditions are: • Roughing speed = 250 r.p.m • Finishing speed = 800 r.p.m • Feed rate (for all cuts) = 0.25 mm/rev • Machining length = 60 mm • Tool approach length = 12 mm Assuming no tool overtravel, Calculate the total machining time required to complete the operation.	8 Marks
	iii)	A lathe machine is equipped with a lead screw of 6 TPI (threads per inch) and a standard change gear set ranging from 20 teeth to 120 teeth in steps of 5, along with a 127-tooth gear available for metric conversion. Design the gear train (including a sketch arrangement description) and calculate the required change gears for cutting the following threads: (a) A metric thread of 5.5 mm pitch (b) A unified inch thread of 1/14 inch pitch (c) A non-standard imperial thread of 2.75 TPI pitch	12 Marks

End of the Question Paper

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Department of Mechanical & Automotive Engineering

BSc Hons (Eng.) Mechanical Engineering

BSc Hons (Eng.) Automotive Engineering

Semester 6 Re-Sit Examination 2026

Module Code	:	**ME3325**
Module Title	:	**Electro- Mechanical Control Systems**
Date	:	**09 February 2026**
Examiners	:	**Kapila Khemaratne**
Time Allowed	:	**(9. 00 am – 12.00 noon) - 3 hrs.**

Instructions to Candidates:

- This is a **closed** book examination.
- This paper consists of Five (05) questions. Answer **all five** questions.
- Use only the answers booklet, additional papers for your answers.
- Write clearly and legibly with a blue or black pen.
- Write your name and student number on all sheets.
- Answers to different parts of the same question (other than any graph sheets used) should not be scattered.
- You are advised to make a clear diagram for each question, where appropriate. This will help you to perform calculations correctly.
- If you have any doubt regarding the interpretation of the wording of a question, make your own assumptions and clearly state them on the answer script.

01. Two pneumatic cylinders are used in an automatic material sorting system. The materials to be transmitted are done by conveyer belts.

When cylinder "Z_1" is actuated, the path "W1" will be opened and cylinder "Z_2" is actuated, both the connection of "W2" and "W3" will be switched by means of an internal linking device. The cylinders are so work, to get different combination of tracks to sort out materials as shown in figure below.

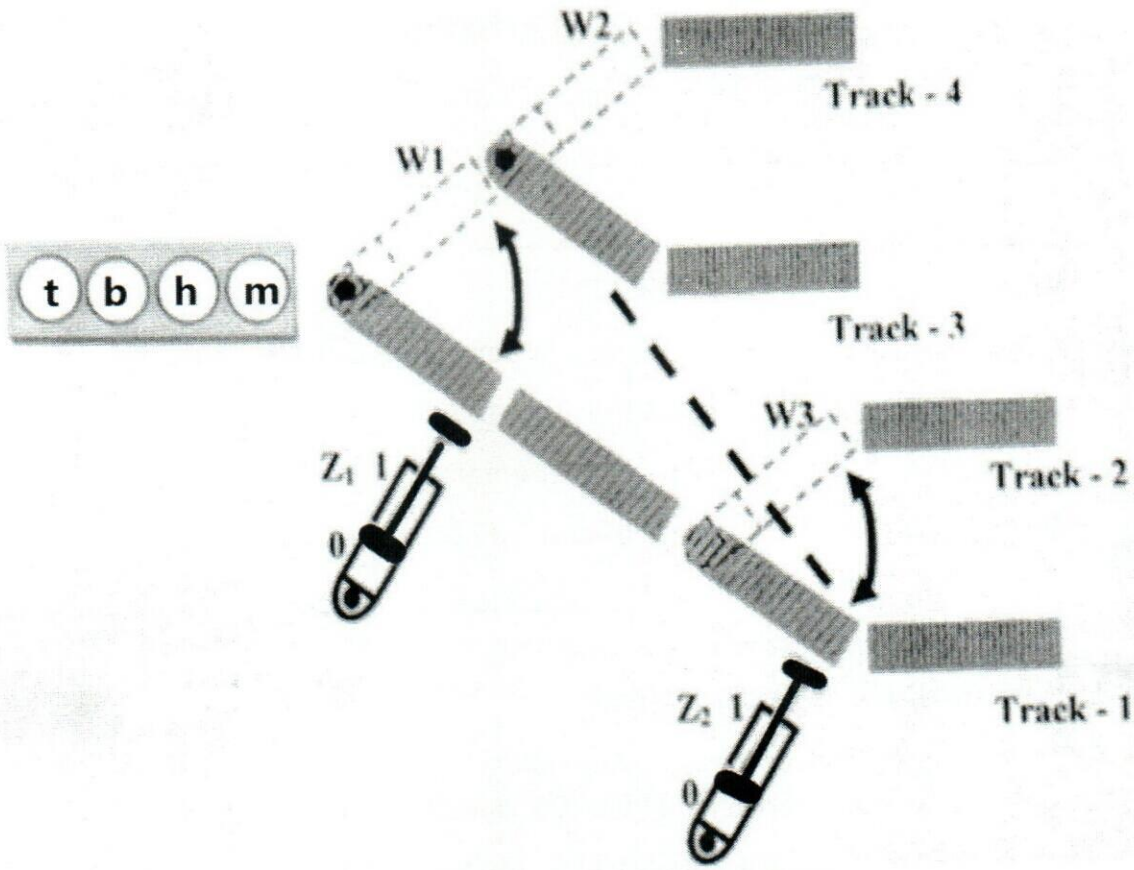


Figure-1 Automatic material sorting system

Four boundary sensors are felt the physical quantities of the materials and always deliver a "1" signal if the quantities t, b, h and m of the adjusted values exceeded. In the other cases signal "0" will be given. Track-3 should remain for emergency reserved and not used.

Table-1

t	b	h	m	Track

0	0	0	0	4
0	0	0	1	4
0	0	1	0	1
0	0	1	1	1
0	1	0	0	1
0	1	0	1	1
0	1	1	0	4
0	1	1	1	2
1	0	0	0	1
1	0	0	1	1
1	0	1	0	4
1	0	1	1	2
1	1	0	0	4
1	1	0	1	2
1	1	1	0	4
1	1	1	1	4

Derive expressions for each cylinder using Karnaugh- Veitch diagrams. **(100 marks)**

02.

(a) Classify type of **air compressors**. **(25 marks)**

(b) Briefly explain the function of '**Service Unit**' with help of sketches where necessary. **(25 marks)**

(c) "**Selection of a correct Air Compressor is very important**" justify the statement. **(25 marks)**

(d) List out and sketch any two **Relief valves** used in Hydraulic circuits. **(25 marks)**

03. Containers are to be filled of silica crystals from a hopper. If it is ensured that a container is under the filler opening, cylinder 1 must be extended by a push button. Once cylinder 1 reached its end position, it's remaining there 5 seconds and retraction takes place.

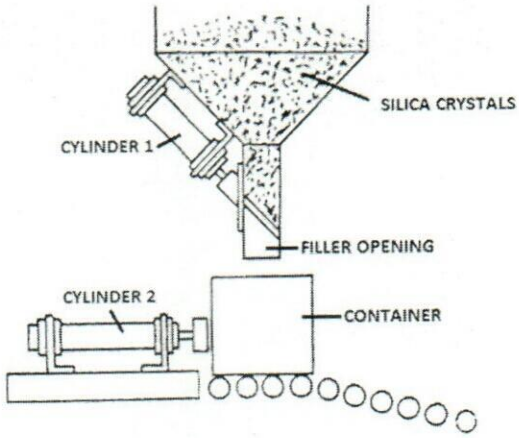


Figure-3 Silica crystal filling station

After retraction of this cylinder, it takes 3 seconds to start the second cylinder extension. Only after complete driving out this cylinder 2 it is brought immediately.

(a) Draw Displacement-Step Diagram, **(25 marks)**

(b) Design a pneumatic circuit diagram. **(75 marks)**

04. Briefly explain the sequence of operation of the electro-pneumatic circuit diagram given below (**Figure-4-b**) when you press either start button S7 or S8.

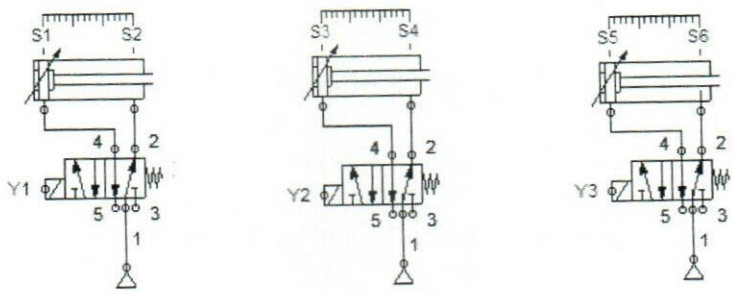


Figure-4-a Pneumatic circuit

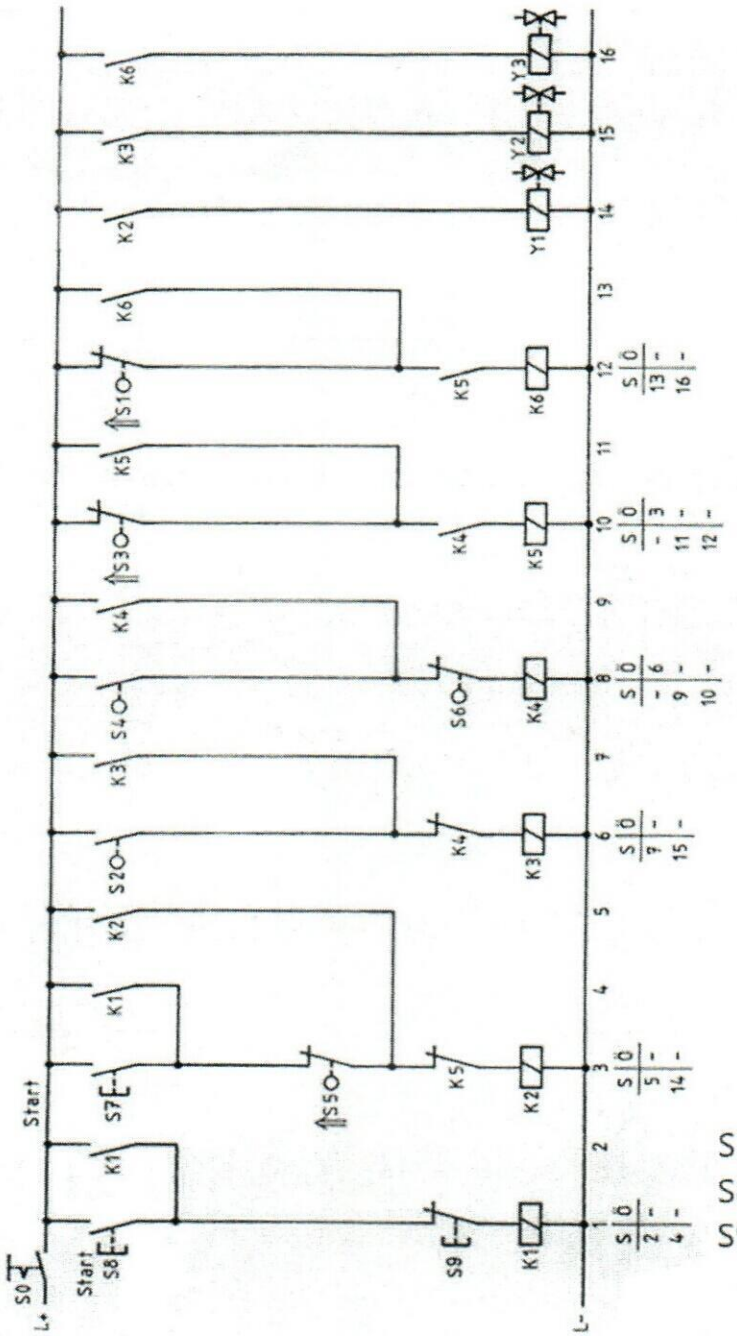


Figure-4-b Electro-pneumatic circuit diagram

(100 marks)

05. Write a suitable program for PLC using any language familiar to you to obtain the operations as in the Displacement - Step diagram given below.

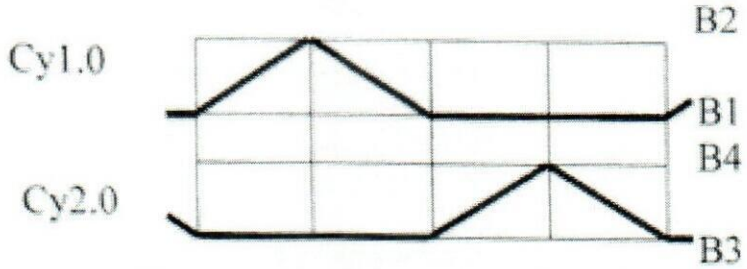


Figure- 5-a Displacement – Step Diagram

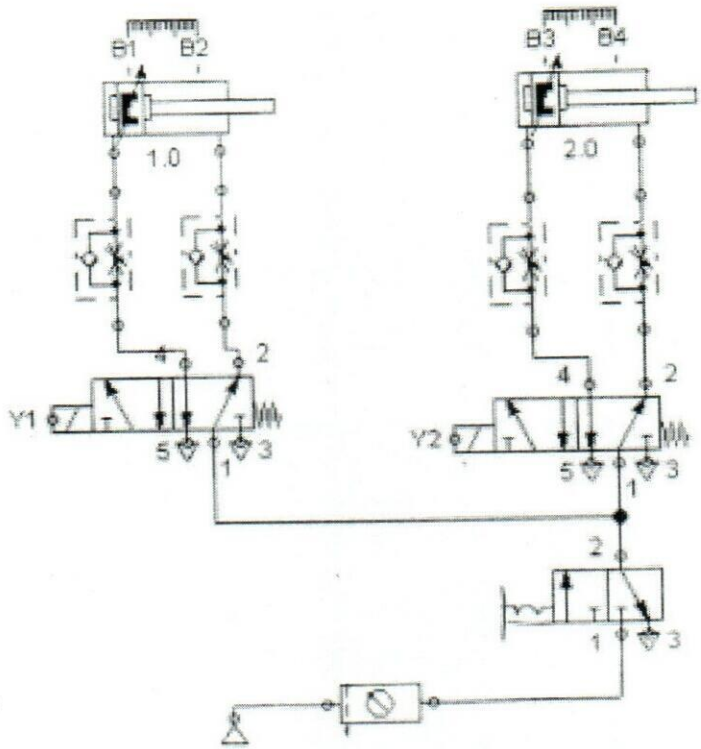


Figure-5-b Pneumatic circuit

(100marks)

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Faculty of Engineering & Technology

Department of Mechanical & Automative Engineering

BSc Hons (Eng) Mechatronics Engineering

Semester 6 Resit - Examination 2025

Module Code	:	**ME3326**
Module Title	:	**Computational Thermo-Fluid Dynamics**
Date	:	**February 7, 2026**
Examiners	:	**Dr. Geethal Siriwardana**
Time Allowed	:	**(09 00 am – 12.00 noon)- 3 hrs.**

Instructions to Candidates:

- This is a **closed** book examination.
- This paper consists of Five (05) questions. Answer **all five** questions.
- Use only the answers booklet and additional papers for your answers.
- Write clearly and legibly with a blue or black pen.
- Write your name and student number on all sheets.
- Answers to different parts of the same question (other than any graph sheets used) should not be scattered.
- Marks will be deducted for missing or incorrect measuring units.
- You are advised to make a clear diagram for each question, where appropriate. This will help you to perform calculations correctly.
- If you have any doubt regarding the interpretation of the wording of a question, make your own assumptions and clearly state it on the answer script.

Question 01

a) Define shear stress and describe how it develops in a moving fluid. **[05 Marks]**

b) Explain the difference between laminar flow and turbulent flow. **[05 Marks]**

c) A pipe flow system where air at pressure P forces fluid from a large tank through a pipe of total length of 90 m that contains a series of valves and fittings. The discharge is at atmospheric pressure. All the elements are in the same horizontal plane. The pipe and all components are 50 mm in diameter and made of Galvanized Iron. The pipeline is connected through six 90° standard elbows, two 45° standard elbows, three gate valves which are fully open, and one quarter open valve respectively, two tees with run flow, another tee with branch flow and a foot valve at the pipe entrance. If the flow rate is 0.4 m^3/min, compute P by the K factor method. The density and the dynamic viscosity of the fluid are 998 kg/m^3 and 1.002x 10^{-3} Pas respectively. K- factors can be found on table Q1.C. **[10 Marks]**

Table Q1.C: k-Factors

Type of fitting	K factor
90-degree standard elbow	0.9
45-degree standard elbow	0.45
Gate Valves - fully open	2.5
Gate Valve - quarter open	5.5
Tee with run flow	0.4
Tee with branch flow	1.6
Foot valve	0.81
Entrance loses	0.75
Exits lose	0.85

K-Factor Loss Equation

$$h_L = K.\left(\frac{V^2}{2g}\right)$$

Darcy Weisbach Formula

$$h_f = \frac{4fLV^2}{2gd}$$

Note: Notations have their usual meanings.

Question 02

a) Explain the limitations of Analytical Fluid Dynamics that led to the development of CFD. **[05 Marks]**

b) Discuss how CFD complements Experimental Fluid Dynamics in modern engineering practice. **[05 Marks]**

c) Discuss the trade-off between mesh density and computational cost. **[05 Marks]**

d) Explain how problem physics determines the choice between steady-state and transient analysis. **[05 Marks]**

Question 03

a) Discuss the role of numerical methods in the advancement of CFD. **[02 Marks]**

b) Discuss the importance of discretization techniques in CFD development. **[04 Marks]**

c) Why is discretization necessary in CFD? Describe how continuous equations are transformed into algebraic equations suitable for numerical computation. **[04 Marks]**

d) A horizontal pipe of 5 meters in length and 0.1 meters in diameter carries water at room temperature. The fluid enters the pipe through an inlet with a uniform velocity of 0.5 m/s. The outlet of the pipe is open to the atmosphere. The pipe wall is maintained at a constant temperature of 50°C, and the water enters at 15°C. Assume the flow is steady, incompressible, and turbulent. The pipe is aligned with the x-axis, and gravity effects can be neglected. Identify and define the appropriate boundary conditions (BCs) required to perform a CFD simulation of this problem:

i. Type of boundary condition (e.g., velocity inlet, pressure outlet, wall). **[04 Marks]**

ii. Associated values or parameters. **[04 Marks]**

iii. Any assumptions need to apply the BCs correctly. **[02 Marks]**

Question 04

a) Develop the governing equation for one-dimensional heat transfer through a large plane wall using the energy balance approach. **[06 Marks]**

b) Derive the equation developed in part (a) under the following conditions: **[04 Marks]**

i. When the material has variable conductivity.

ii. When the material has constant conductivity with steady state.

iii. When the material has constant conductivity with transient, no heat generation.

iv. When the material has constant conductivity with steady state, no heat generation.

c) A 4-m-high and 6-m-wide wall consists of a long 15 cm × 25 cm cross section of horizontal bricks (k = 0.72 W/m·K) separated by 3 cm thick plaster layers (k = 0.22 W/m·K). There are also 2 cm thick plaster layers on each side of the wall, and a 2 cm thick rigid foam (k = 0.026 W/m·K) on the inner side of the wall. The indoor and the outdoor temperatures are 22° C and −4° C, and the convection heat transfer coefficients on the inner and the outer sides are h_1 = 10 W/ m^2 ·K and h_2 = 20 W/ m^2 ·K, respectively. Assuming one-dimensional heat transfer and disregarding radiation, determine the rate of heat transfer through the wall. **[10 Marks]**

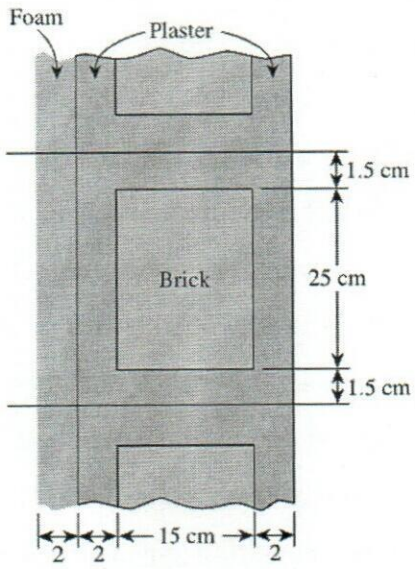


Figure Q4.C

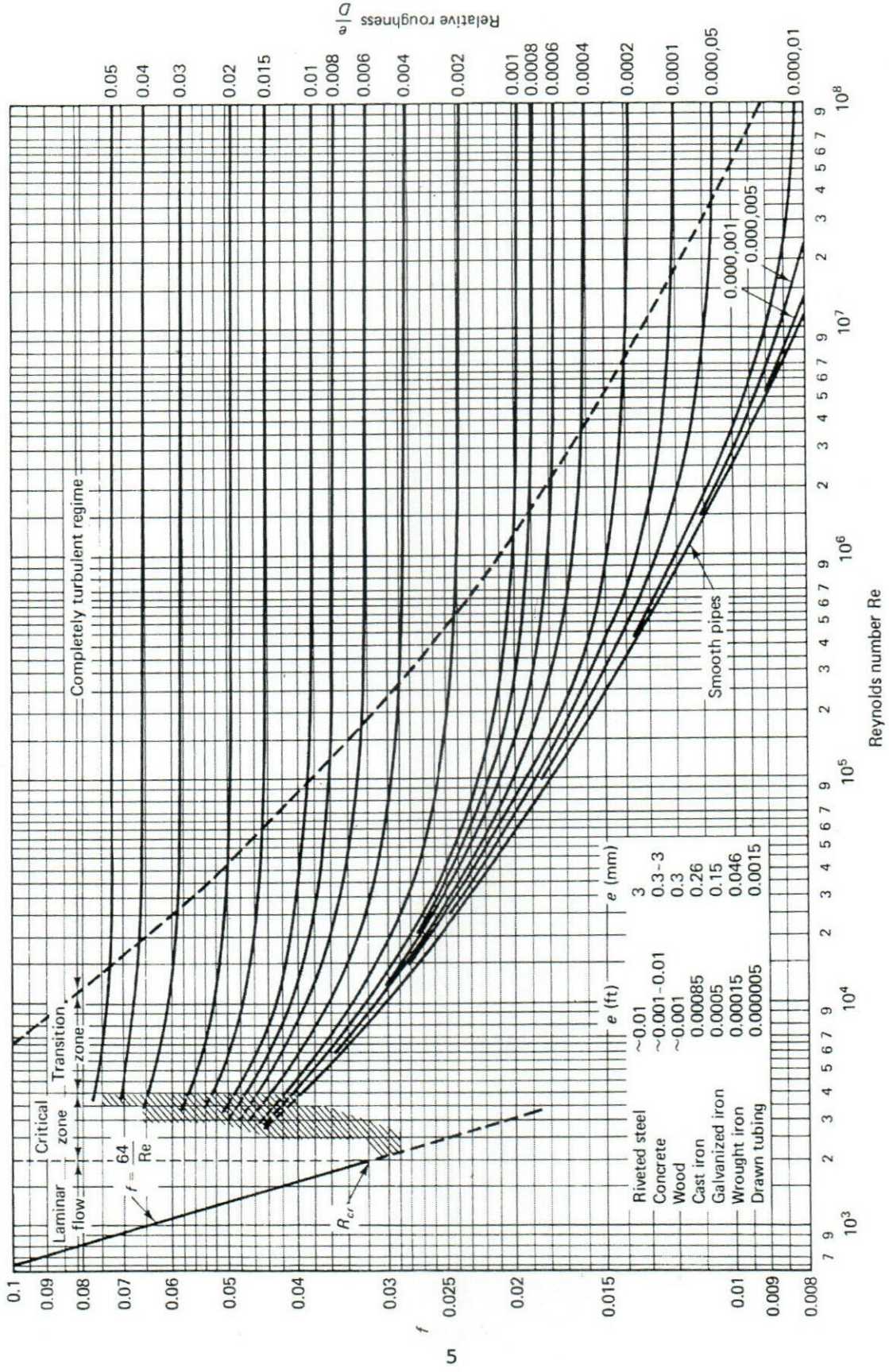
Question 05

a) Under what conditions can a gas flow be treated as incompressible. **[05 Marks]**

b) Define speed of sound and explain its role in compressible flow. **[05 Marks]**

c) Explain the difference between static and stagnation properties. **[05 Marks]**

d) Describe the measurement of stagnation pressure using a Pitot tube. **[05 Marks]**


Relative roughness $\frac{e}{D}$
0.05
0.04
0.03
0.02
0.015
0.01
0.008
0.006
0.004
0.002
0.001
0.0008
0.0006
0.0004
0.0002
0.0001
0.000,05
0.000,01
Completely turbulent regime
Transition zone
Critical zone
Laminar flow
$f = \frac{64}{Re}$
R_{cr}
Smooth pipes
0.000,001
0.000,005
e (ft)
e (mm)
Riveted steel ~0.01 3
Concrete ~0.001–0.01 0.3–3
Wood ~0.001 0.3
Cast iron 0.00085 0.26
Galvanized iron 0.0005 0.15
Wrought iron 0.00015 0.046
Drawn tubing 0.000005 0.0015
f
Reynolds number Re
10^3
10^4
10^5
10^6
10^7
10^8

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Department of Mechanical & Automotive Engineering

BSc. Hons. (Eng.) in Mechanical Engineering

BSc. Hons. (Eng.) in Automotive Engineering

Semester 5 Re Sit Examination 2026

Batch : 05

Module Code: ME3323	**Module Title : Machine Design**
Date: 05th February 2026	**Duration: 03 Hours**
Examiner	**P.D.Sarath Chandra**

Instructions to Candidates:

- ***This is a closed book examination. No reference materials are allowed unless specified.***
- ***This paper consists of four (4) questions and 10 pages. Answer all questions.***
- ***The marks allocated to each question are listed in the column on the far right. Final mark of the question paper will be calculated out of 100.***
- ***Use only the provided answer booklet, additional sheets, and graph papers for your answers.***
- ***Write clearly and legibly. Use a blue or black pen only.***
- ***Write your student number on all sheets.***
- ***Start each question on a new page in the answer booklet, answer sheets. Clearly indicate the question number at the top of the page.***
- ***If parts of the same question are written discontinuously in non-consecutive sheets, ensure that each part is relevantly labelled with its corresponding question number.***
- ***Use the Psychrometric chart and the other data provided for answering questions 03 and 04.***
- ***Attach the Psychrometric chart with your answer booklet.***

Question 1 – 50 marks

A steel machine shaft, 75 mm in diameter and 250 mm in length, is modeled as a cantilever, as shown in **Figure Q1**. The shaft is subjected to a 300 Nm torsional moment, a 20 kN axial tensile force, and a 3000 N vertical downward force at the free end. The directions of the forces and the moment are shown in the figure.

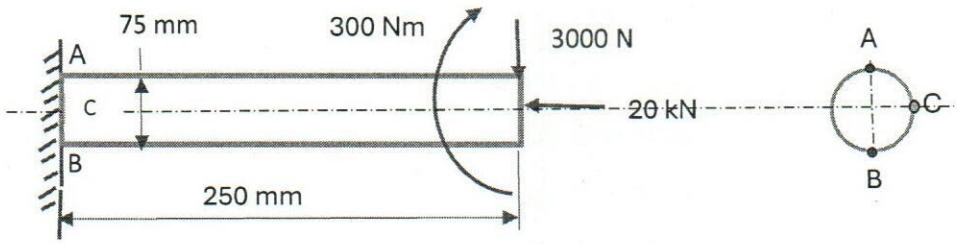


Figure Q1

A sample of shaft material was tested, and results show that the material has **Ultimate Strength** (tensile), S_{ut} = 650 MPa, and Tensile Yield Strength (S_{yt}) of 380 MPa. **Shear Yield Strength** is obtained from these test results.

Calculate the stresses prescribed on table below relevant to points A, B and C of the shaft as shown in the figure and fill in the cells as required. Copy the table without the last column and present the answers in the answer book.

i) Present all relevant analytical calculations clearly in the answer book.

***Use (+) sign for Tensile and (-) sign for compressive stresses.**

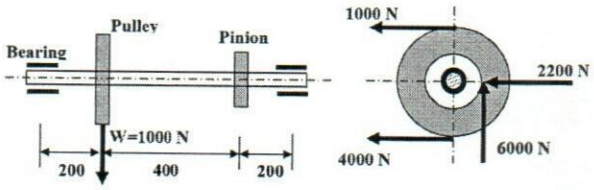
Quantity to be calculated	Point A	Point B	Point C		Marks Assigned
Bending stress due to Bending Moment (MPa)					05
Direct stress due to axial force (MPa)					03
Stress due to Torsional moment					04
Maximum Principal Stress (MPa) with the sign*					10
Minimum Principal Stress (MPa) with the sign*					10
Maximum Shear Stress (MPa) based on the principal stresses					10
Safety Factor relevant determined with Maximum Shear stress					05

ii) Which point (A or B or C) is at a high risk of failure? Justify answer. [03 marks]

Question 2 – 100 marks

Figure Q2 illustrates the schematic configuration of a simple power transmission system, of which the shaft is supported at both ends by bearings spaced 0.8 meters apart. A driven pulley (of which the driving pulley is not shown), weighing 1000 N, is mounted on the shaft at a position 200 mm to the right of the left bearing. This driven pulley transmits power to a pinion whose weight is considered comparatively negligible, positioned 400 mm to the right of the pulley. The pinion, in turn, drives an external machine element not illustrated in the figure. The diameters of the pulley and pinion are 400 mm and 200 mm, respectively.

The belt tensions, and reactions on the pinion are as shown in the figure.



Answer the following questions. Use the A.S.M.E Code wherever appropriate.

i) Determine the bearing reactions in vertical and horizontal planes. [12 marks]

ii) Draw the loading and bending moment diagrammes in the horizontal plane. [16 marks]

iii) Draw the loading and bending moment diagrammes in the vertical plane. [16 marks]

iv) Draw the resultant bending moment diagramme. [10 marks]

v) Determine the torque values relevant to the pulley and the pinion wheel. [08 marks]

vi) Sketch the torsional moment distribution over the span of the shaft. [05 marks]

vii) Considering the values of the bending moment diagrammes and the torsional moment digramme, determine the critically stressed point of the shaft. [08 marks]

viii) If the shaft material has a tensile yield strength (S_{yt}) of 380 MPa and an ultimate tensile strength (S_{ut}) of 650 MPa, with a design factor of 1.5, and the pulley and pinion are keyed to the shaft, what allowable stress should be considered when applying the A.S.M.E Code equation? [10 marks]

ix) Hence, calculate the minimum diameter for the shaft with shock and fatigue factors for bending (k_b) and that for torsion (k_t) are 2.0 and 1.5 respectively. [15 marks]

Question 3 – 50 marks

The bolted assembly shown in **Figure Q3** has been preloaded by the tightening nut to reach an initial preload, P_i. The stiffnesses are $\mathbf{k_b}$ for bolt, $\mathbf{k_1}$ for material **I** and $\mathbf{k_2}$ for material **II respectively**. Neglect the stiffness of the washers.

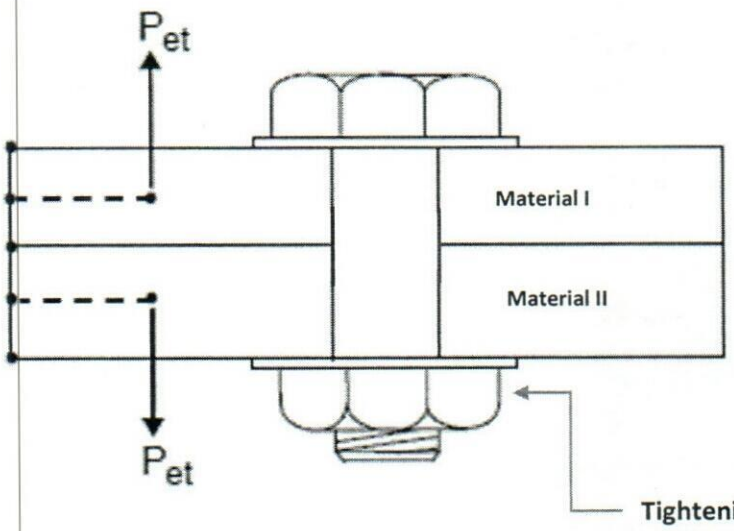


Figure Q3

i) Using the spring analogy develop and expression for **equivalent stiffness ($\mathbf{k_m}$)** for the clamped material. [04 marks]

ii) Illustrate the elastic behavior of the bolt as one component and that of the clamped materials as a single combined component in a Load vs. Elongation graph. Represent their behavior under the preload (P_i) and after applying the external load (P_{et}), considering the case, where (P_{et}) is less than the external load required for separation. **Bolt** material has stiffness, $\mathbf{k_b}$ and equivalent stiffness of **clamped** material is $\mathbf{k_m}$. [10 marks]

iii) Hence or otherwise, show that the final bolt load P_b and that in the clamped material P_m are given by

$$P_b = P_i + P_{et}\left(\frac{k_b}{k_b + k_m}\right), \text{ and } P_m = P_i - P_{et}\left(\frac{k_m}{k_b + k_m}\right)$$ [10 marks]

iv) Formulate the condition that when the value of external load reaches the value, $P_i\left(\frac{k_b + k_m}{k_m}\right)$, the clamped materials are just about to separate. [06marks]

v) A flanged compressor-cylinder is held to its crank case by means of symmetrically placed, identical bolts, designated as **M 18 x 2.5 C** with stress area of each bolt, 1.92 cm^2 and with a gasket in between contact area of the cylinder flange and the head. Inside cylinder diameter is 250 mm. The effect of each bolt of the joint can be modelled as that given in **Figure Q3**. The maximum compression pressure developed inside cylinder is 4 MPa. The bolt material has yield stress (S_{yt}) of 600 MPa. The initial tightening load on each bolt is 51.2 kN and the ratio, $k_b : k_m = 1 : 1$.

a) Assuming a design factor of 1.5, determine the stress in a bolt before the bolt-stress reaches the allowable stress that can be safely stand against applied external load? (06 marks)

b) Estimate the number of bolts required to hold the cylinder on to the cylinder-head. [06 marks]

c) If the cylinder pressure increases above 4 MPa, what should be the magnitude of external load when the joint is about to separate? [08 marks]

Question 4 – 50 marks

i) Explain why a V-belt drive can transmit more power than a flat belt drive, assuming all operating conditions are identical except for the belt and pulley geometry. [04 marks]

ii) In belt drive systems, it is the standard design practice to position the tight side of the belt at the bottom and the slack side at the top. On what operational and mechanical reasons can this configuration be justified? [04 marks]

iii) A flat belt is required to transmit 15 kW power from a pulley 1200 mm diameter running at 250 rpm to another pulley, which runs at 450 rpm. The centre distance between the pulleys is 2.7 m. Coefficient of friction between the belt and pulley is 0.25. If the safe working stress for belt is 17,500 N/m, density of the belt material is 1000 $kg.m^{-3}$ and the thickness of the belt is 10 mm, what width of the belt would be required if centrifugal tension taking into account.
(Assume if the width of the belt is w in meters, the allowable tension is 17500 w in Newton.)

Sketch the belt drive system illustrating the design parameters and **answer** the following questions. [03 marks]

i) What is the linear velocity of the belt? Should the belt velocity be significant, and should it be considered in belt design calculations? [05 marks]

ii) Find the angle of wrap for both the driven and driving pulleys. [06 marks]

iii) Which pulley (driver or driven) primarily governs belt design? Why? [04 marks]

iv) Calculate the centrifugal tension in the belt? [06 marks]

v) Determine the value of width of the belt *(w)* based on the conditions given. [10 marks]

vi) At what speed is maximum power transmitted if the initial tension set of the belt is 3500 N? [04 marks]

vii) What is the maximum power at this speed? [04 marks]

Question 5 – 50 marks

A **square** thread power screw has a **major** diameter 32 mm and a **pitch** of 4 mm with **double** threads. This power screw with the nut is used to raise or lower 6.4 kN load. Coefficient of friction for threads and collar is 0.08. Mean diameter of the collar is 40 mm.

Answer the following questions.

i) Calculate (using the thread geometry) thread depth, thread width, mean thread diameter (pitch diameter) and the lead. (05 marks)

ii) Determine the torque required to be applied at the thread pitch diameter of the screw to **raise** the load. (10 marks)

iii) Determine the torque to overcome the friction applied at the collar-mean diameter, assuming uniform rate of wear. (05 marks)

iv) What is the overall torque required to **raise** the load? (05 marks)

v) Answer questions ii), iii) and iv to **lower** the load. (15 marks)

vi) Estimate the efficiency of the power screw taking the collar friction into account. (10 marks)

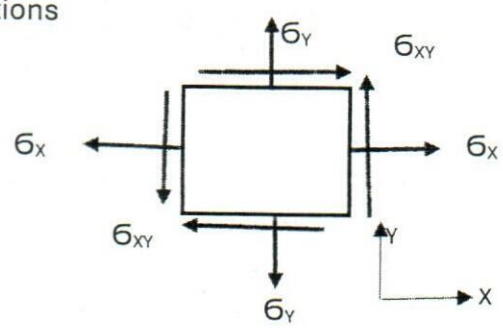
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Formulas and DATA for Machine Design QUESTION PAPER

All equations are presented in standard notations

$$\sigma_{1/2} = \left(\frac{\sigma_X - \sigma_Y}{2}\right) \pm \sqrt{\left(\frac{\sigma_X + \sigma_Y}{2}\right)^2 + \tau_{XY}^2}$$

$$\tau_{max} = \frac{\sigma_1 - \sigma_2}{2}$$



$\frac{M}{I} = \frac{\sigma_b}{y}$; $\frac{M_t}{J} = \frac{\tau}{r}$, M_t = Externally applied Torsional Moment, M_t is torsional moment, and M is bending moment.

ASME Code

$\tau_d = 0.30\ S_{yt}$

$\tau_d = 0.18\ S_{ut}$

Whichever is the smallest out of the above two values is considered. This value is further reduced by 25% for the power transmission shafts with keyways to accommodate gears and/or pulleys. Design code is applied to this value.

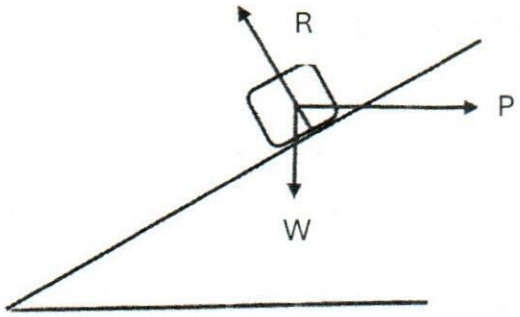
From the Maximum Shear Stress Theory, $\tau_{max} = \frac{16}{\pi d^3}\sqrt{(k_b M)^2 + (M_t k_t)^2}$, At the critically stressed point on the shaft, M is the bending moment and M_t is the torque.

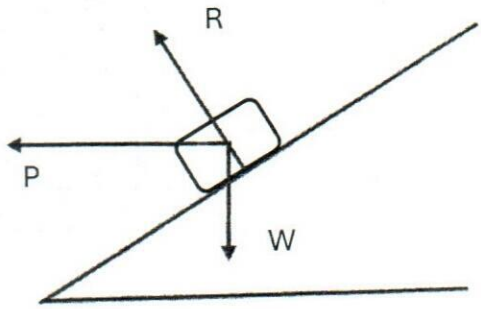
For a flat belt drive:

$\frac{T_1 - T_c}{T_2 - T_c} = e^{\mu \propto}$, where α is the angle of wrap and μ is the coefficient of friction between belt and pulley materials. $T_c = mv^2$ = Centrifugal Tension of the belt, m = linear density of the belt

When initial tension and centrifugal tension are taken into consideration, the power transmitted, (P) at the belt velocity, v is given as follows:

$P = 2\,(T_0 v - mv^3)\left[\frac{1 - e^{-\mu\alpha}}{1 + e^{-\mu\alpha}}\right]$, where v is the belt velocity and T_0 is the initial tension of the belt. This equation can be used to determine the velocity of the belt at which the maximum power is transmitted and the maximum power transmission.





$$P = W\,Tan\,(\alpha + \emptyset)$$

$$P = W\,Tan\,(\alpha - \emptyset)$$

W is the load to be raised or lowered; P is the effort; α is the helical angle of the thread and $\mu = Tan^{-1}(\Phi)$

$Tan\,\alpha = \frac{l}{\pi d_m}$, where d_m is the mean thread diameter.

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Faculty of Engineering & Technology Department of Mechanical and Automotive Engineering BSc. Hons. (Eng.) in ME/AE/E&E/ MT Engineering Semester 6 - Resit Examination 2026 Batch : 5	
Module Code: FE3321	**Module Title: Management For Engineers**
Date: 02 Feb 2026	**Duration: 3 hours**
Examiner 1: **Examiner 2:**	**Eng. Asantha Sumanarathna**

Instructions to Candidates:

- *This is a closed book examination. **No** reference materials are allowed unless specified.*
- *This paper consists of two sections (Section A has 10 MCQs & Section B has 4 essay type questions) and altogether 5 pages. **Answer all questions.***
- *The marks allocated to each question are listed in the column on the far right. Final mark of the question paper will be calculated out of 100.*
- *Use only the provided answer booklet, additional sheets, and graph papers for your answers.*
- *Write clearly and legibly. Use a blue or black pen only.*
- *Write your student number on all sheets.*
- *Start each question on a new page in the answer booklet, answer sheets. Clearly indicate the question number at the top of the page.*
- *If parts of the same question are written discontinuously in non-consecutive sheets, ensure that each part is relevantly labelled with its corresponding question number.*

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	SECTION B	Marks
Q1	(i) Discuss the **evolution of management thought**, highlighting how management theories have adapted to modern organizations.	10
	ii) Explain how these theories can be applied in managing contemporary engineering organizations.	10
Q2	(i) Explain the **functions of management** with suitable engineering examples.	10
	(ii) Discuss how effective planning and organizing contribute to project success.	10
Q3	Discuss the importance of **Human Resource Management** in engineering organizations. Answer should include recruitment, training, performance management, and relevant **legal aspects of industrial relations**.	20
Q4	(ii) Explain the **basic concepts of marketing** relevant to engineers.	10
	(ii) Discuss how engineers can contribute to marketing activities in an engineering-based organization using suitable examples.	10

SECTION - A

Student Reg. / ID No : .....

Notes:

1. This section consists of **10** multiple choice questions (MCQs).
2. Select the correct answer and **circle** the relevant alphabetical letter A, B, C or D.
3. Answer all the questions and return this Section A paper.
4. All correct answers carry **2 marks** each (Total 20 marks for section A)

MCQ 1: Henri Fayol's main contribution to management theory was the development of: (**2** Marks)

A. Scientific management and time–motion studies
B. Bureaucratic organizational principles
C. General principles and functions of management
D. Human relations and motivation theory

MCQ 2: Which of the following best distinguishes classical management from modern management approaches? (**2** Marks)

A. Classical focuses on human behavior; modern focuses on structure
B. Classical emphasizes flexibility; modern emphasizes rigid rules
C. Classical is qualitative; modern is purely quantitative
D. Classical emphasizes efficiency and structure, while modern emphasizes systems and human factors

MCQ 3: An organizational structure can best be defined as: (**2** Marks)

A. The formal arrangement of roles, responsibilities, authority, and communication
B. The informal relationships among employees
C. The strategic plan of an organization
D. The leadership style adopted by management

MCQ 4: One major objective of having a formal organizational structure in an engineering organization is to: (**2** Marks)

A. Increase informal communication
B. Reduce the number of employees
C. Eliminate conflicts completely
D. Clearly define authority, responsibility, and reporting relationships

P T O =>

MCQ 5: Which of the following is a characteristic of a functional organizational structure? (**2** Marks)

A. Employees report to both functional and project managers
B. Project teams are fully autonomous
C. Employees are grouped based on specialized engineering functions
D. Authority is decentralized to project teams

MCQ 6: An engineering organization using a matrix structure is most likely to have: (**2** Marks)

A. Only one clear line of authority
B. Dual reporting relationships for engineers
C. No functional specialization
D. Complete independence of project teams

MCQ 7: Managerial decision making is best described as: (**2** Marks)

A. The process of choosing the best course of action among alternatives
B. Selecting employees for key positions
C. Implementing organizational policies
D. Delegating authority to subordinates

MCQ 8: Which of the following is the first step in the rational decision-making process? (**2** Marks)

A. Evaluating alternatives
B. Implementing the decision
C. Selecting the best alternative
D. Identifying and defining the problem

MCQ 9: The primary role of technology management in improving organizational competitiveness is to: (**2** Marks)

A. Replace human labor with machines
B. Align technological capabilities with business strategy
C. Reduce employee training needs
D. Eliminate research and development activities

MCQ 10: Professional ethics in engineering mainly refers to: (**2** Marks)

A. Adhering to moral principles and professional standards in engineering practice
B. Obeying instructions from superiors
C. Maximizing profits for the organization
D. Avoiding responsibility for design failures

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FACULTY OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

BSC HONS (ENG) IN MECHANICAL ENGINEERING / MECHATRONIC ENGINEERING

BATCH 04 - SEMESTER 08

RESIT EXAMINATION

SEPTEMBER 2025

Module Code	:	**ME4322**
Module Title	:	**Maintenance & Reliability Engineering**
Date	:	**08th September 2025**
Examiners	:	**Mr. Vijitha Abesundara**
Time Allowed	:	**3 Hours (13:30hrs – 16:30hrs)**

Instructions to Candidates:

- This is a **closed book** examination. No reference materials are allowed.
- This paper consists of **FIVE (05)** questions. Answer **ALL** questions.
- Use only the provided answer booklet and additional sheets.
- Write clearly and legibly using a blue or black pen.
- Write your student number on **ALL** sheets.
- ***Start each question on a new page in the answer booklet. Clearly indicate the question number at the top of the page.***
- If parts of the same question are written discontinuously in different sheets, ensure that each part is appropriately labelled with its corresponding question number.
- Where appropriate, include clear diagrams or sketches. These can aid in calculations and help convey your answers effectively.
- If you are unsure about the wording of a question consult the Supervisor or Invigilator, or make reasonable assumptions. Clearly state such assumptions in your answer script.
- Marks will be deducted for missing or incorrect measuring units, and failure to adhere to the above instructions.
- You may use a scientific calculator but it must not be programmable.

Question 1

a) Discuss the differences between predictive and preventive maintenance with suitable examples.

(20 marks)

b) Name and discuss the important areas that you must consider when improving the quality of maintenance activities.

(20 marks)

c) Discuss the factors which affect the Mean Down Time (MDT) of equipment.

(20 marks)

d) Discuss the steps that you can adopt to minimize the MDT.

(20 marks)

e) Discuss the differences between Inherent Availability and Operational Availability.

(20 marks)

Question 2

a) Discuss the challenges that you will face when planning and implementing your maintenance program.

(20 marks)

b) Discuss the importance of Preventive Maintenance.

(15 marks)

c) Discuss the risks involved in Preventive Maintenance

(15 marks)

d) Activities shown in Table Q1 given below are to be completed in order to repair the cooling system.

Table Q1

Activity	Immediate Predecessor	Duration in hrs.
A	No	3
B	A	4
C	A	6
D	B	6
E	B	4
F	C	4
G	D	6
H	E, F	8

I. Draw the Network Diagram

(30 marks)

II. Find the Critical Path

(10 marks)

III. What activities are you recommending in order to minimize the total completion time.

(10 marks)

Question 3

a) Discuss the suitability and advantages of Centralized Maintenance System. (25 marks)

b) Discuss the issues that you have to consider when scheduling your maintenance activities. (25 marks)

c) Discuss the importance of "Time Standards" in maintenance. (25 marks)

d) Discuss the main components of Maintenance Cost. (25 marks)

Question 4

a) Discuss the differences between "Intrinsic Availability" and "Operational Availability". (30 marks)

b) Failure details of a Mobile Crane during the last six months (180 days) are given in Table Q4.
Find

I. Availability of the Mobile Crane during the given period. (30 marks)

II. Mean Time Between Failures (MTBF) (20 marks)

III. Mean Time to Repair (MTTR) (20 marks)

Table Q4

Failure No	Time in Days in Last 6 months	
	Failure Occurred	Failure Corrected
1	12.8	13.0
2	14.2	14.8
3	25.4	25.8
4	31.4	33.3
5	35.3	35.6
6	56.4	57.3
7	62.7	62.8
8	131.2	134.9
9	146.7	150.7
10	177.0	177.1

Question 5

a) Discuss the differences between Hot Standby and Warm Standby in parallel standby systems.

(20 marks)

b) Discuss the differences between Switching Failures and Standby Failures in parallel standby systems

(20 marks)

c) Discuss critical factors that have to be taken into consideration when deciding Redundancy Allocation in parallel systems

(20 marks)

d) Find if the Cumulative Distribution Function for times to failure is,

$1 - [100/(t + 10)^2]$

I. The failure rate as a function of time.

(20 marks)

II. Does the failure rate increase or decrease with time.

(20 marks)

****** End of the Question Paper ******

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Faculty of Engineering & Technology

Department of Mechanical & Automotive Engineering

BSc Hons (Eng.) Mechanical Engineering

BSc Hons (Eng.) Mechatronics Engineering

Semester 8 Re-sit - Final Examination 2025

Module Code	:	**ME4329**
Module Title	:	**Renewable Energy Systems**
Date	:	**30 August 2025**
Examiners	:	**Gamini Wijesundara**
Time Allowed	:	**(1. 30 pm – 4.30 pm) - 3 hrs.**

Instructions to Candidates:

- This is a **closed** book examination.
- This paper consists of Five (05) questions. Answer **all five** questions.
- Use only the answers booklet, additional papers and graph paper for your answers.
- Write clearly and legibly with a blue or black pen.
- Write your name and student number on all sheets.
- Answers to different parts of the same question (other than any graph sheets used) should not be scattered.
- Marks will be deducted for missing or incorrect measuring units.
- You are advised to make a clear diagram for each question, where appropriate. This will help you to perform calculations correctly.
- If you have any doubt regarding the interpretation of the wording of a question, make your own assumptions and clearly state them on the answer script.

QUESTION 01

(a) Briefly explain the global environmental impact on energy usage. [06 marks]

(b) What are the factors responsible for global energy crisis? Explain briefly. [06 marks]

(c) Sri Lanka is heavily dependent on fossil fuels for its energy requirements. What steps would you suggest to reduce this dependency? Explain. [08 marks]

QUESTION 02

(a) Sketch the power curve for a typical horizontal axis wind turbine and indicate the following parameters on it.

(i) Cut in speed

(ii) Rated wind speed

(iii) Cut out wind speed [05 marks]

(b) What is meant by Betz Limit? Explain briefly [03 marks]

(c) A 50 m diameter, three bladed horizontal axis wind turbine produces 300 kW at a wind speed of 10 m/s.

(i) Determine the theoretical power available in the wind. [03 marks]

(ii) Determine the rotational speed of the rotor if the tip speed ratio is 5.5. [03 marks]

(iii) If the generator runs at 2000 rev/min, what gear ratio is needed to match the rotor speed with the generator speed? [03 marks]

(iv) What is the overall efficiency of the wind turbine system (including blades, gearbox, and generator) under these conditions. [03 marks]

Take density of air as 1.3 kg/m^3

QUESTION 03

(a) Sketch a schematic diagram of a passive solar water heating system and label the main components. [04 marks]

(b) Calculate the annual energy delivered by a 1 kW (DC, STC) array if it receives an insolation of 6.4 peak Sun hours per day. Use an overall derating factor of 72%. [04 marks]

(c) A household of four people consume an average of 50 liters per person per day of hot water at 40°C. The temperature of cold water is 25°C. To meet the demand for hot water it has been decided to install a solar water heater.

Determine the following using the given data.

(i) Energy required in kWh/day of hot water for this household. [04 marks]

(ii) Collector area necessary for this demand. [04 marks]

(iii) Energy produced by the collectors in kWh/day. [04 marks]

Additional Data

- Density of water – 1000 kg/m^3
- Heat capacity of water – 0.00116 kWh/kgK
- System efficiency – 45%
- Solar fraction – 70%
- Solar radiation – 5 kWh/m^{2}day
- Absorption coefficient of the collector – 0.9

- Transmission coefficient of glazing – 0.95

QUESTION 04

(a) Explain the advantages and disadvantages of using hydropower. [06 marks]

(b) A hydroelectric plant has 15 identical Francis turbines, a gross head of 300 m, and a volume flow rate of 15 m^3/s through each turbine. The efficiencies are: $\eta_{Turbine} = 95.9\%$, $\eta_{Generator} = 94.2\%$, $\eta_{Other} = 95.6\%$, where η_{Other} accounts for all other mechanical power losses.

Calculate the amount of electrical power produced from this plant in MW. Take density of water as 1000 kg/m^3. [04 marks]

(c) A Pelton wheel is used to produce hydroelectric power. The average radius of the wheel is 1.2 m, and the jet velocity is 80 m/s from a nozzle of exit diameter 12 cm. The turning angle of the buckets is 165°. Determine the following.

(i) Flow rate through the turbine in m^3/s. [03 marks]

(ii) Rotational speed of the wheel in rev/min, if the ratio of the bucket speed to the speed of the jet is 0.45. [03 marks]

(iii) Output shaft power in MW if the efficiency of the turbine is 90%. [04 marks]

QUESTION 05

(a) List the categories of offshore wave energy converters and briefly explain the operation of one such type. [05 marks]

(b) Sketch the layout of a single – basin tidal power plant and briefly explain how this plant works. [05 marks]

(c) What are the advantages of geothermal plants? Explain briefly. [05 marks]

(d) 'Biomass conversion technologies can be broadly classified into three basic categories. State these categories and explain one of them briefly. [05 marks]

Some Useful Equations (in usual notations)

$$P_{AC} = P_{DC,STC} \times \text{Derating factor}$$

$$Q_{required} = \rho V C (T_{hot} - T_{cold})$$

$$\eta_{system} = \frac{Q_{used}}{Q_{sol}}$$

$$Q_{sol} = I_{sol} \times A_{col}$$

$$F_s = \frac{Q_{used}}{Q_{required}}$$

$$Q_i = \alpha t \times I_{sol} A_{col}$$

$$\dot{W}_{ideal} = \rho \omega r \dot{V} (V_j - \omega r)(1 - \cos\beta)$$

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Faculty of Engineering & Technology

Department of Mechanical & Automotive Engineering

BSc Hons (Eng.) Mechanical Engineering

Semester 8 Re Sit - Final Examination 2025

Module Code	:	**ME4238**
Module Title	:	**Advanced Automotive Systems Engineering**
Date	:	**30th August 2025**
Examiners	:	**S D R Perera**
Time Allowed	:	**(1.30 noon – 4.30 noon)- 3 hrs.**

Instructions to Candidates:

- This is a **closed** book examination.
- This paper consists of Five (05) questions. Answer **all five** questions.
- Use only the answers booklet, additional papers and graph paper for your answers.
- Write clearly and legibly with a blue or black pen.
- Write your name and student number on all sheets.
- Answers to different parts of the same question (other than any graph sheets used) should not be scattered.
- Marks will be deducted for missing or incorrect measuring units.
- You are advised to make a clear diagram for each question, where appropriate. This will help you to perform calculations correctly.
- If you have any doubt regarding the interpretation of the wording of a question, make your own assumptions and clearly state it on the answer script.

Question 1

a) Following information is given with respect of a vehicle (LO1)

Mass of the truck	2500	kg
Maximum gradient which the truck will have to negotiate	12	deg
Maximum Velocity at the maximum grade	40	km/h
Gear engaged while driving at the maximum gradient	1st	gear
Coefficient of rolling resistance	0.016	
Aerodynamic drag coefficient	0.33	
Total projected frontal area	3	m^2
Transmission efficiency in the first gear	80	%
Effective diameter of the road wheel	700	mm
Gear reduction ratio in the differential drive unit	4	

You may also assume that the density of air is 1.293 kg/m3

Determine,

i. The minimum power available at the engine speed of 2400 rpm. On the 1st gear **(8 marks)**

ii. The maximum speed of the vehicle in the top gear on level road at the engine speed of 2000 rpm **(8 marks)**

iii. The gear ratio in the top gear for the condition given in (b) above **(4 marks)**

Question 02

a) Sketch a typical power split device that is being used in modern series parallel hybrid configurations with two motor generators and an IC engine and identify major components **(08 mars)**

b) Referring to the sketch you have drawn for the part a of this question, explain how the following operating modes are obtained

i. Operating on the Motor Generator 2 only **(03 marks)**

ii. Operating on the IC engine only **(03 marks)**

iii. Operating on IC engine while battery charging **(03 marks)**

iv. Operating in reverse (03 marks).

v. Starting the engine when the vehicle is stationary **(03 marks)**

Question 03

a) Explain the operating principle of a typical Gasoline Direct Ignition engine. **(08 marks)**

b) Explain the main strategies used in Gasoline Direct Injection (GDI) engines to improve the efficiency. Please note that you are required to highlight the techniques used specifically in GDI engines **(12 marks)**

Question 04

a) By means of a block diagram, depict a typical Simscape model of an electric vehicle. **(14 marks)**

b) Describe the operating principle of the electric vehicle model created on Simscape **(06 marks)**

Question 5

a) According to new emission regulation requirements, the engine control module must determine if a misfire is occurring and further diagnose and identify the specific cylinder(s) and the severity of the misfire event. Explain how the ECU is designed to detect such faults. **(08 marks)**

b) A schematic diagram of a BLDC motor controller is shown in Figure. Explain how a Brush less DC motor is controlled by means of such a controller. **(12 marks)**

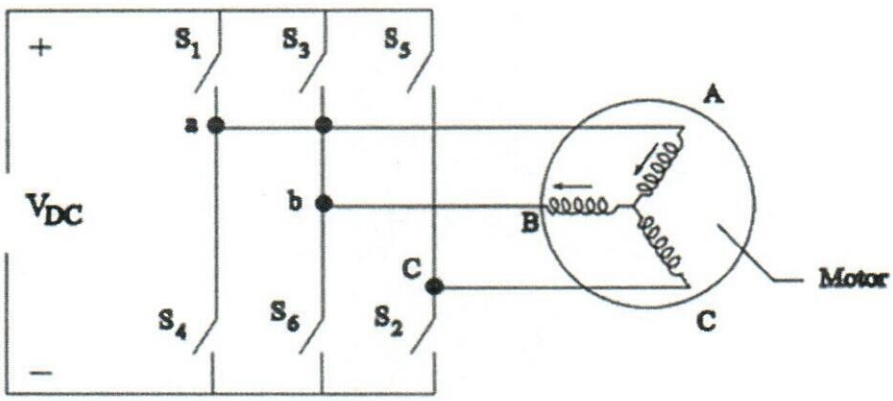


Figure- 5-b

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Department of Mechanical & Automative Engineering

BSc Hons (Eng) Mechanical / Automotive Engineering

Semester 5 Resit Examination 2025

Module Code	:	**ME3312**
Module Title	:	**Heat Engines & Heat Transfer Devices**
Date	:	**10th August 2025**
Examiner	:	**Hasitha Wipulaguna**
Time Allowed	:	**3 Hours**

Instructions to Candidates:

- This is a **closed** book examination.
- This paper consists of five (05) questions. Answer **all questions**.
- Use only the answers booklet and additional papers for your answers.
- Write clearly and legibly with a blue or black pen.
- Write your name and student number on all sheets.
- Answers to different parts of the same question (other than any graph sheets used) should not be scattered.
- Marks will be deducted for missing or incorrect measuring units.
- You are advised to make a clear diagram for each question, where appropriate. This will help you to perform calculations correctly.
- If you have any doubt regarding the interpretation of the wording of a question, make your own assumptions and clearly state them in the answer script.

QUESTION 01 [20 marks]

Steam at 7 bar and dryness fraction of 0.9 expands in a cylinder behind a piston isothermally and reversibly to a pressure of 1.5 bar.

i) Calculate the change of internal energy and the change of enthalpy per kg of steam.

ii) If the heat supplied during the process is found to be 547 kJ/kg Calculate the work done per kg of steam.

QUESTION 02 [20 marks]

Air at 15^0C and 1.05 bar occupies 0.02 m^3. The air is heated at constant volume until the pressure is 4.2 bar, and then cooled at constant pressure back to the original temperature.

(For air R = 0.287 kJ/kgK , γ =1.4)

i) Sketch the process on a T-s diagram.

ii) Calculate the net heat flow to or from the air and the net entropy change.

QUESTION 03 [20 marks]

A car engine with a power output of 65 hp has a thermal efficiency of 24 percent. Determine the fuel consumption rate of this car if the fuel has a heating value of 19,000 Btu/lbm (that is, 19,000 Btu of energy is released for each lbm of fuel burned).

QUESTION 04 [20 marks]

A heat pump is used to meet the heating requirements of a house and maintain it at 20 ^{0}C. On a day when the outdoor air temperature drops to -20 ^{0}C, the house is estimated to lose heat at a rate of 80,000 kJ/h.

If the heat pump under these conditions has a COP of 2.5, determine

(a) the power consumed by the heat pump

(b) the rate at which heat is absorbed from the cold outdoor air.

QUESTION 05 [20 marks]

The interior lighting of refrigerators is provided by incandescent lamps whose switches are actuated by the opening of the refrigerator door. Consider a refrigerator whose 40W light bulb remains on continuously as a result of a malfunction of the switch .

If the refrigerator has a coefficient of performance of 1.3 and the cost of electricity is 12 cents per kWh, determine the increase in the energy consumption of the refrigerator and its cost per year if the switch is not fixed.

----------END OF EXAMINATION PAPER ----------

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Faculty of Engineering & Technology

Department of Mechanical & Automotive Engineering

BSc Hons (Eng.) Automotive Engineering

Semester 5 Re Sit - Final Examination 2025

Module Code	:	**EE3313**
Module Title	:	**Automotive Electronics**
Date	:	**3rd August 2025**
Examiners	:	**S. D. R. Perera**
Time Allowed	:	**(13.30 – 16.30) - 3 hrs.**

Instructions to Candidates:

- This is a **closed** book examination.
- This paper consists of Five (05) questions. Answer **all five** questions.
- Use only the answers booklet, additional papers and graph paper for your answers.
- Write clearly and legibly with a blue or black pen.
- Write your name and student number on all sheets.
- Answers to different parts of the same question (other than any graph sheets used) should not be scattered.
- Marks will be deducted for missing or incorrect measuring units.
- You are advised to make a clear diagram for each question, where appropriate. This will help you to perform calculations correctly.
- If you have any doubt regarding the interpretation of the wording of a question, make your own assumptions and clearly state on the answer script.

Question 01

(a) For the circuit diagram shown in Figure Q1 (a), determine I_1, I_2 and I_3. (10 marks)

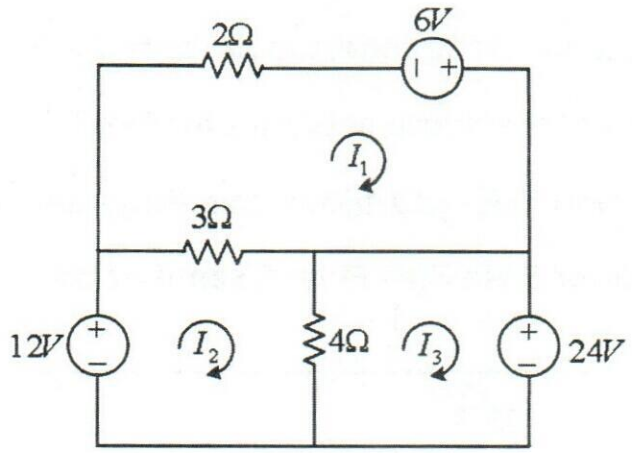


Figure Q1(a)

(b) For the transistor configuration shown in Figure Q1(b) determine the Ib Ic and Vce. (10 marks)

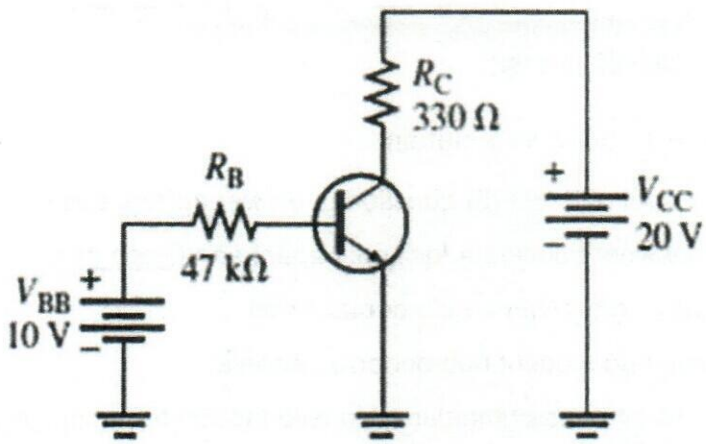


Figure Q1 (b)

Question 02.

A failsafe function is a very important feature in electronically controlled engines.

(a) Explain how the ECU would recognise the malfunction of an air flow sensor. (10 marks)

(b) Explain how the ECU would implement a failsafe feature in the absence of a signal from the air flow sensor. (10 marks)

Question 03

(a) By means of a sketch, explain the operating principle of a conventional ignition system (08 marks)

(b) Explain what dwell angle is. (04 marks)

(c) Explain how the dwell angle is adjusted in an ECU controlled EFI engine (08 marks)

Question 04

(a) Sketch a typical electronic power steering system with main components and sensors (10 marks).

(b) Explain the operating principle of two main sensors employed in the electronic power steering system. (10 marks)

Question 05

A typical voltage regulator for an alternator is shown in Figure Q5. Explain its operating principle in detail with specific reference to main individual components. (20 marks)

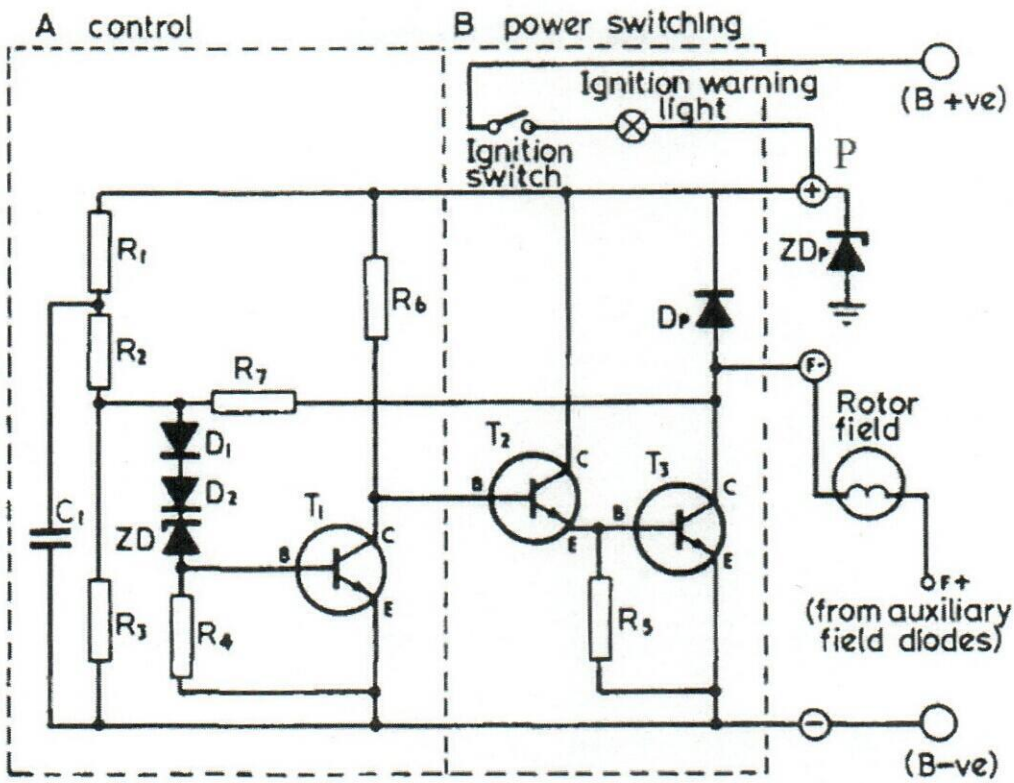


Figure Q5 – Voltage regulator

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Faculty of Engineering & Technology

Department of Mechanical & Automative Engineering

BSc Hons (Eng) Mechanical Engineering

Semester 8 First Sit - Final Examination 2025

Module Code	:	**ME4326**
Module Title	:	**Energy Management**
Date	:	**28th August 2025**
Examiners	:	**Dr. Geethal Siriwardana**
Time Allowed	:	**(09 00 am – 12.00 noon)- 3 hrs.**

Instructions to Candidates:

- This is a **closed** book examination.
- This paper consists of Five (05) questions. Answer **all five** questions.
- Use only the answers booklet, additional papers and graph paper for your answers.
- Write clearly and legibly with a blue or black pen.
- Write your name and student number on all sheets.
- Answers to different parts of the same question (other than any graph sheets used) should not be scattered.
- Marks will be deducted for missing or incorrect measuring units.
- You are advised to make a clear diagram for each question, where appropriate. This will help you to perform calculations correctly.
- If You have any doubt regarding the interpretation of the wording of a question, make your own assumptions and clearly state it on the answer script.

Question 01

a) Illustrate with examples how renewable energy sources can replace conventional energy sources. **[05 Marks]**

b) Discuss the concept of energy flow with reference to efficiency and losses in industrial energy conversion. **[05 Marks]**

c) Explain the social and economic consequences of fossil fuel dependence in Sri Lanka and suggest solutions. **[05 Marks]**

d) Describe how energy efficiency can be improved in practical systems while adhering to the first law of thermodynamics. **[05 Marks]**

Question 02

a) Identify and briefly explain three levels of energy audits. **[03 Marks]**

b) What is the purpose of a Terms of Reference (TOR) in a system-specific energy audit? **[03 Marks]**

c) Explain how you would prioritize and implement energy conservation measures identified during a detailed audit of a manufacturing plant. **[04 Marks]**

d) A standard 75 kW electric motor with 80% efficiency is to be replaced by a high-efficiency motor with 90% efficiency. The motor operates 5500 hours per year at full load. The electricity cost is Rs. 30/kWh.

i. Calculate the energy saved per year. **[04 Marks]**

ii. Calculate the monetary savings. **[04 Marks]**

iii. If the cost of the new motor is Rs. 1,300,000 and the old motor's replacement cost is Rs. 500,000, estimate the simple payback period. **[02 Marks]**

Question 03

a) Describe how ISO 50001 helps organizations establish an Energy Management System (EnMS). **[02 Marks]**

b) Explain how PDCA supports monitoring, measurement, and corrective action in energy management. **[08 Marks]**

c) Discuss the challenges and benefits of designing a green building that complies with international certification systems. **[10 Marks]**

Question 04

a) Discuss best practices for optimizing steam traps and condensate return to improve energy management. **[05 Marks]**

b) Illustrate with a diagram the main components of a steam distribution network including traps and return lines. **[05 Marks]**

c) Explain how blowdown and stack gas losses are quantified using heat and mass balance equations. **[05 Marks]**

d) Describe three examples of equipment used for industrial waste heat recovery. **[05 Marks]**

Question 05

Lighting systems are among the major energy consumers in commercial buildings.

a) How can smart building automation enhance lighting energy efficiency? Support your answer with four examples. **[08 Marks]**

b) Why is luminous efficacy a key performance metric in LED lighting design? **[04 Marks]**

c) Discuss the relationship between CCT, employee mood, and work performance. **[08 Marks]**

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Department of Mechanical & Automotive Engineering
BSc Hons (Eng) Mechanical Engineering
Semester 8 Re-sit Examination 2025

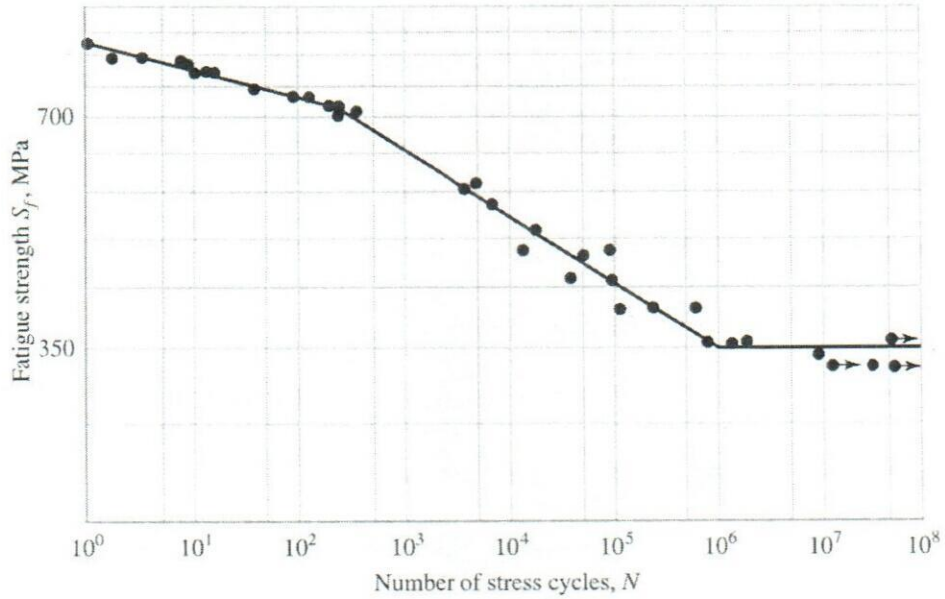
Module Code	:	**ME4327**
Module Title	:	**Product Realisation & Materials**
Date	:	**3rd Aug 2025 / 09.00 -12.00 hrs**
Examiner	:	**T.S. Peiris**
Time Allowed	:	**3 Hours**

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- This paper consists of 5 questions. You Should Answer **ALL** questions.
- Write clearly, legibly with a blue or black pen.
- Use only the **CINEC Answering Booklet**. Additional sheets may be requested from the invigilators.
- **Use Answer sheet for Q1(i) attached at the end of question paper to answer the relevant question. Fill the Index number on this sheet.**
- This paper contains 14 pages.

MATERIALS REQURIED

- CINEC answering Booklet; Extra answering paper,
- You may use a scientific calculator. This must not be programmable. This may be examined during the examination.
- You may use additional data provided at the end of this examination paper.

1.	(i)	Mark the following ranges on the S-N curve shown in Figure Q1(i). Use an additional figure provided for your answer at the end of this question paper. (a) Low cycle fatigue (b) High cycle fatigue (c) Finite Life (d) Infinite Life (e) Ultimate tensile strength (f) Endurance limit.  **Figure Q1(i)**	30%
	(ii)	Fig Q1shows a rotating shaft simply supported in ball bearings A and D. Loaded by non-rotating force F of 6.8 kN. Shaft material is cold drawn 1050 steel. (1kpsi = 6.89476 MPa). (a) Sketch the Bending moment diagram (b) Estimate the endurance limit of rotary beam test (S'_e) (c) Estimate the surface factor (k_a) (d) Estimate the size factor (k_b) (e) Estimate the loading factor (k_c) (f) Estimate the Temperature factor (k_d) (g) Estimate the Reliability factor (k_e (h) Estimate the endurance limit (S_e). (i) Estimate the life of the part.	70%

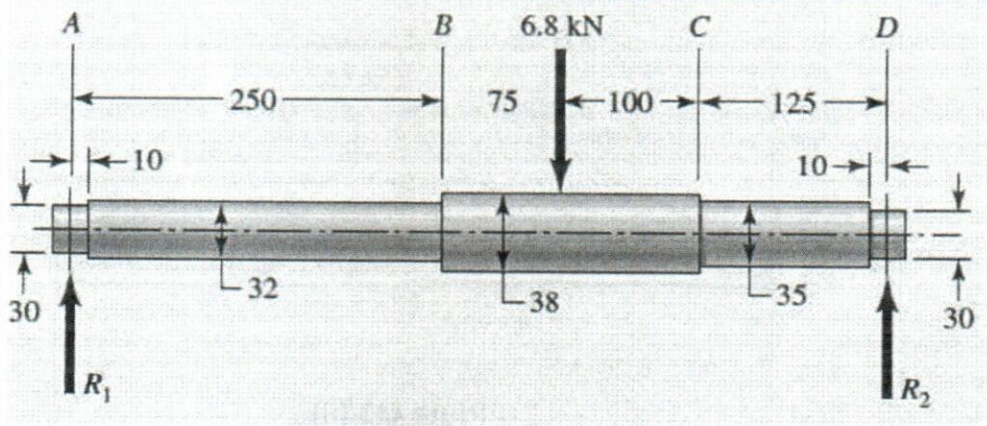


Figure Q1(ii)

2.	**(i)**	Draw three stress – strain diagrams on a same diagram for the following materials. (a) The brittle fiber used to make composite. (b) The ductile matrix material used to make the composite. (c) The composite materials prepared	**30%**
	(iii)	A continuous and aligned glass fiber-reinforced composite consists of 40 vol % of glass fiber having a modulus of elasticity of 69 GPa and 60 vol % of a polyester resin that, when hardened, displays a modulus of 3.4GPa. **(a)** Compute the modulus of elasticity of this composite in the longitudinal direction. **(b)** If the cross-sectional area is 2.50 mm^2 and a stress of 50 MPa is applied in this longitudinal direction, compute the magnitude of the Load carried by each of the fiber and matrix phases. **(c)** Determine the strain that is sustained by each phase when the stress in part (b) is applied. **(d)** Compute the elastic modulus of the composite material when the stress is applied perpendicular to the direction of fiber alignment.	**70%**

3	**(i)**	Sketch the creep curve and name different stages of the curve. Also mark the instantaneous deformation and rupture.	**15%**
	(ii)	Influence of stress and temperature on creep behaviour is shown by the figure Q 3(ii). Discuss this behaviour in detail.	**25%**

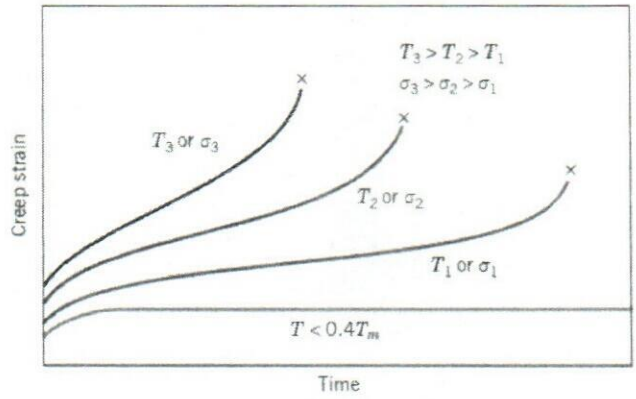


Figure Q3 (ii)

(iii) Steady-state creep rate data for a metal are given in the table below at 533 k:

$\dot{\varepsilon}_s(h^{-1})$	σ (MPa)
3.65	25
2.0×10^{-4}	3

Compute the steady-state creep rate at a stress of 10 MPa and 533 k. **60%**

4 **(i)** **(a)** Explain orthogonal cutting operation and oblique cutting operation with the aid of sketches. **15%**

(b) Explain the generation of build-up edge in metal cutting and give suggestions to avoid generation of build-up edge. **10%**

(ii) The following equation for tool life was obtained for HSS tool

$$VT^{0.13}f^{0.6}d^{0.3} = C$$

A 60 min tool life was obtained using the following cutting condition. V = 40 m/min, f = 0.25 mm, d = 2 mm.

Calculate the effect on tool life if,

(a) The constant (C) of the above equation.
(b) The speed is increased by 25%,
(c) The feed is increased by 25%,
(d) The depth of cut is increased 25% and
(e) All these factors together increased by 25%.

Where f = feed, d = depth and V = speed. **75%**

5.	**(i)**	Describe the Stereo Lithographic Apparatus (SLA) and Digital Light Processing (DLP) with aid of sketches.	**30%**
	(ii)	Describe the benefits and limitations of Vat Polymerisation	**20%**
	(iii)	Describe the applications of Vat Photo-Polymerisation	**20%**
	(IV)	Describe the Top Down and Bottom-Up orientations used in Vat Polymerisation with the aid of sketches.	**30%**

End of Questions

Formula sheet

$$E_{cl} = E_m V_m + E_f V_f$$

$$\varepsilon_c = \varepsilon_m V_m + \varepsilon_f V_f$$

$$\dot{\varepsilon}_s = K_1 \sigma^n$$

$$\dot{\varepsilon}_s = K_2 \sigma^n \exp(-\frac{Q_c}{RT})$$

$$k_a = a S_{ut}^b$$

Table 6–2

Parameters for Marin Surface Modification Factor, Eq. (6–19)

Surface Finish	Factor a S_{ut}, kpsi	Factor a S_{ut}, MPa	Exponent b
Ground	1.34	1.58	−0.085
Machined or cold-drawn	2.70	4.51	−0.265
Hot-rolled	14.4	57.7	−0.718
As-forged	39.9	272.	−0.995

$$k_b = \begin{cases} (d/0.3)^{-0.107} = 0.879 d^{-0.107} & 0.11 \le d \le 2 \text{ in} \\ 0.91 d^{-0.157} & 2 < d \le 10 \text{ in} \\ (d/7.62)^{-0.107} = 1.24 d^{-0.107} & 2.79 \le d \le 51 \text{ mm} \\ 1.51 d^{-0.157} & 51 < d \le 254 \text{ mm} \end{cases} \quad (6\text{–}20)$$

- Applies only for round, rotating diameter
- For axial load, there is no size effect, so $k_b = 1$

$$k_c = \begin{cases} 1 & \text{bending} \\ 0.85 & \text{axial} \\ 0.59 & \text{torsion} \end{cases} \quad (6\text{–}26)$$

Temperature Factor k_d

- Endurance limit appears to maintain same relation to ultimate strength for elevated temperatures as at room temperature
- This relation is summarized in Table 6–4

Table 6–4

Effect of Operating Temperature on the Tensile Strength of Steel.* (S_T = tensile strength at operating temperature; S_{RT} = tensile strength at room temperature; $0.099 \leq \hat{\sigma} \leq 0.110$)

Temperature, °C	S_T/S_{RT}	Temperature, °F	S_T/S_{RT}
20	1.000	70	1.000
50	1.010	100	1.008
100	1.020	200	1.020
150	1.025	300	1.024
200	1.020	400	1.018
250	1.000	500	0.995
300	0.975	600	0.963
350	0.943	700	0.927
400	0.900	800	0.872
450	0.843	900	0.797
500	0.768	1000	0.698
550	0.672	1100	0.567
600	0.549		

$$k_d = \frac{S_T}{S_{RT}} \qquad (6\text{–}28)$$

Reliability Factor k_e

- Simply obtain k_e for desired reliability from Table 6–5.

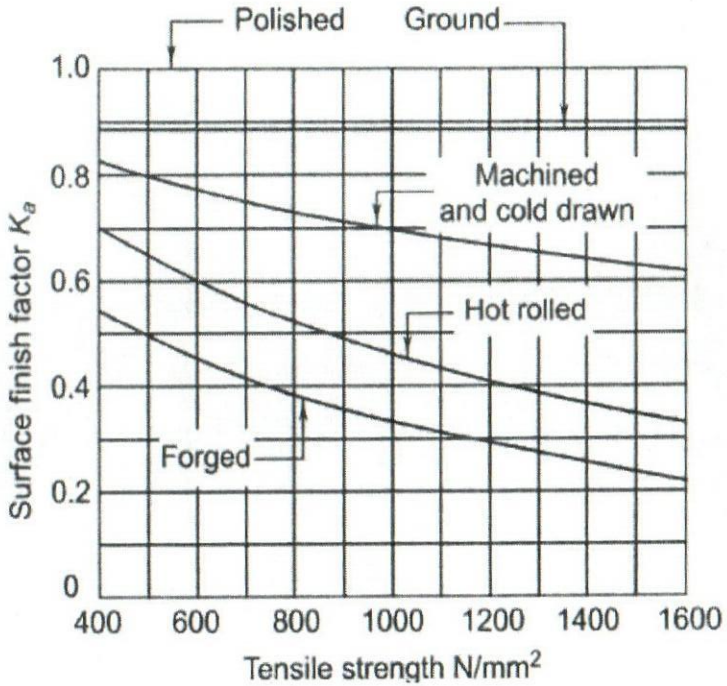
Reliability, %	Transformation Variate z_a	Reliability Factor k_e
50	0	1.000
90	1.288	0.897
95	1.645	0.868
99	2.326	0.814
99.9	3.091	0.753
99.99	3.719	0.702
99.999	4.265	0.659
99.9999	4.753	0.620

Table 6–5

Reliability Factor Table for 8% Standard Deviation

Reliability R (%)	K_e
50	1.000
90	0.897
95	0.868
99	0.814
99.9	0.753
99.99	0.702
99.999	0.659

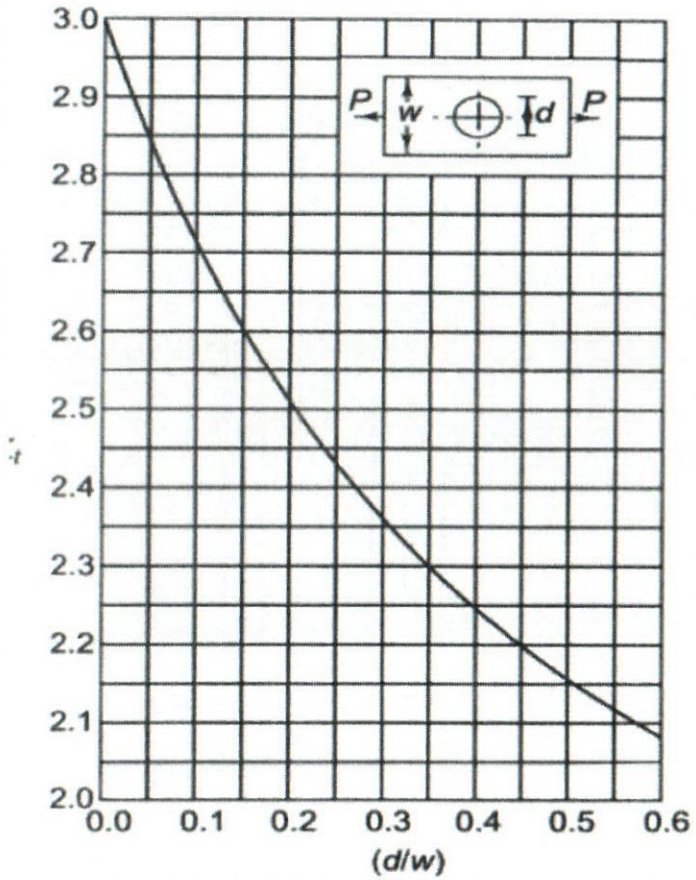
Surface finish factor



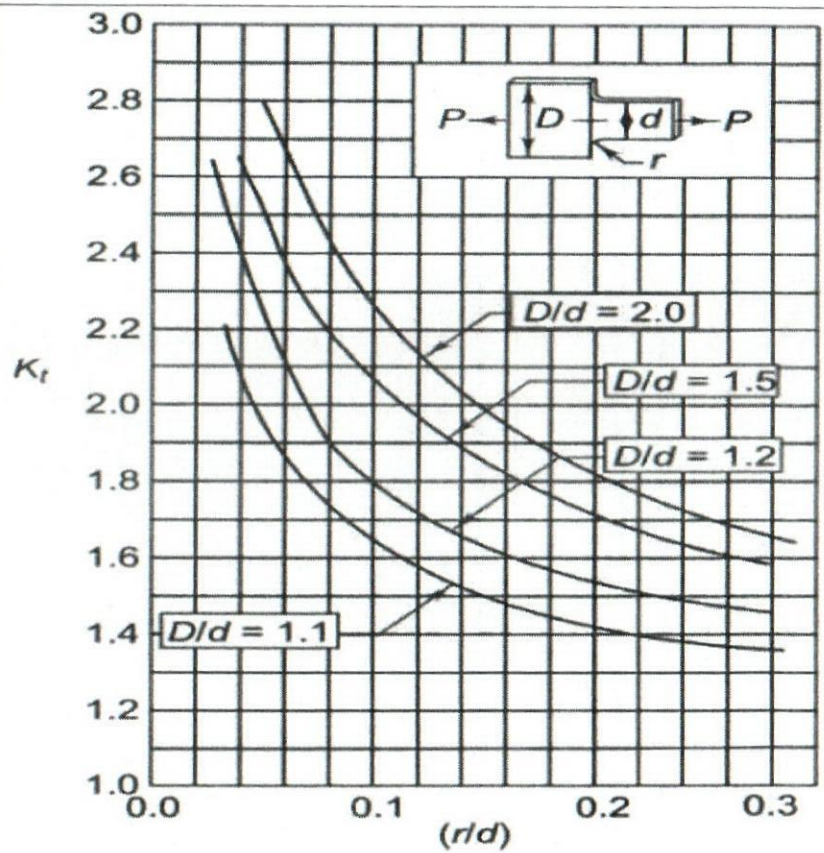
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The charts for the stress concentration factor

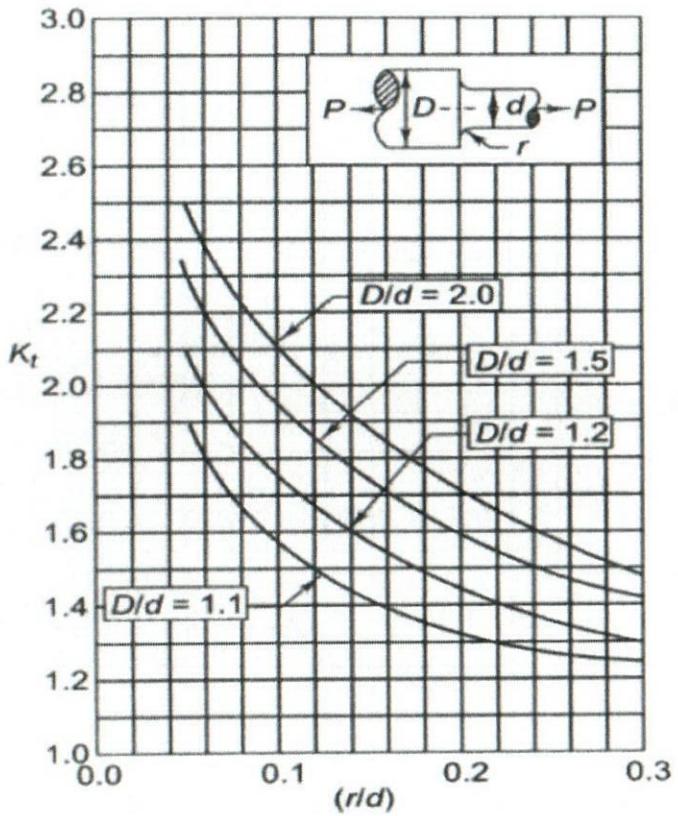
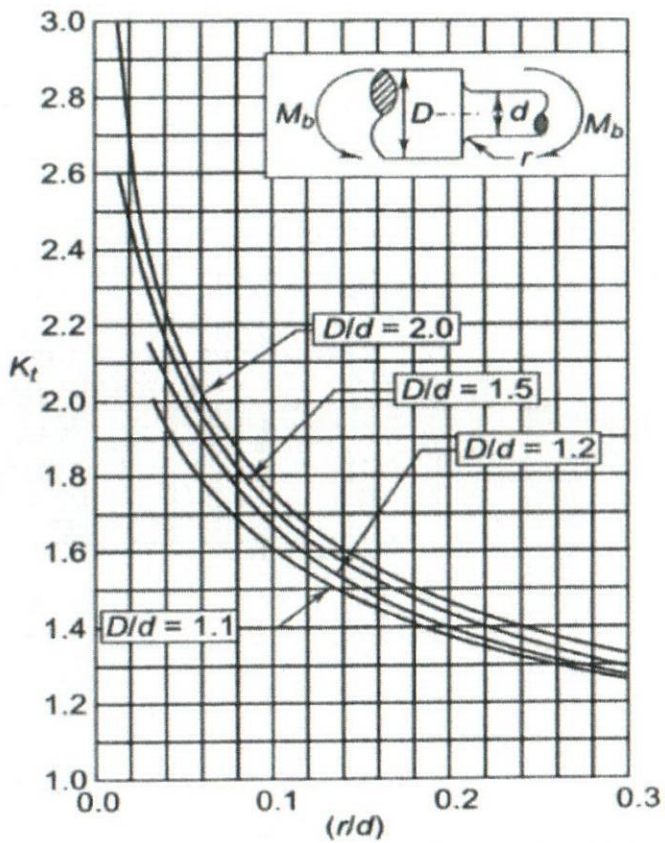
A rectangular plate with a transverse hole loaded in tension or compression.



A flat plate with a shoulder fillet subjected to tensile or compressive force.



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Round Shaft with shoulder fillet subjected to Tensile Force	Round shaft with shoulder fillet subjected to Bending Moment.
	

00011

Round shaft with shoulder fillet subjected to Torsional Moment.

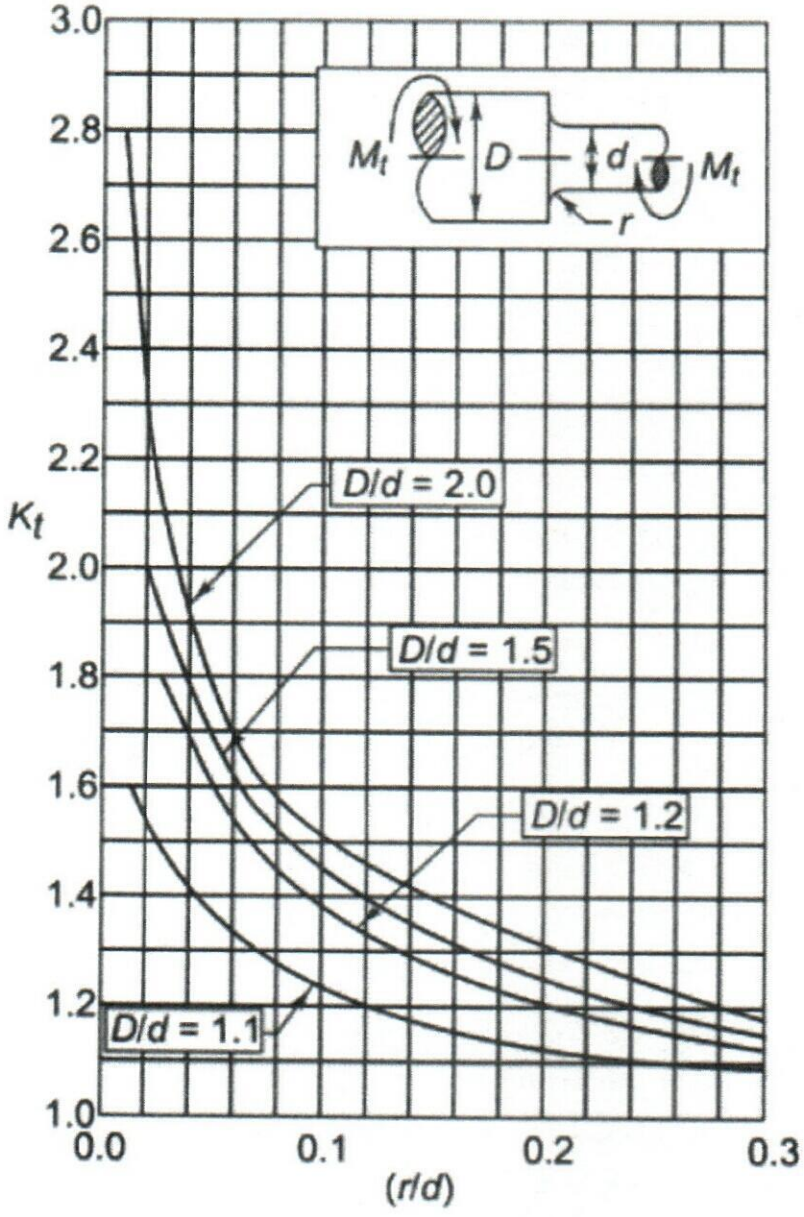


Figure 6–20

Notch-sensitivity charts for steels and UNS A92024-T wrought aluminum alloys subjected to reversed bending or reversed axial loads. For larger notch radii, use the values of q corresponding to the $r = 0.16$-in (4-mm) ordinate. *(From George Sines and J. L. Waisman (eds.),* Metal Fatigue, *McGraw-Hill, New York. Copyright © 1969 by The McGraw-Hill Companies, Inc. Reprinted by permission.)*

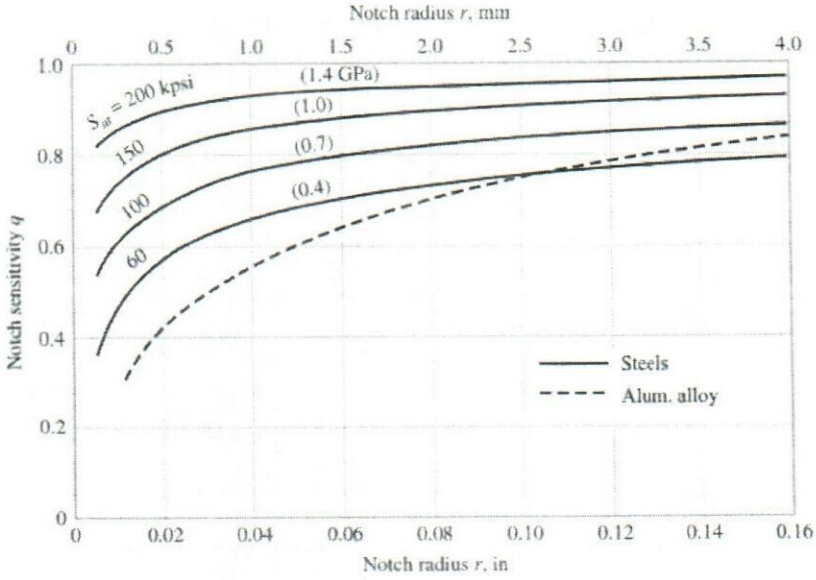
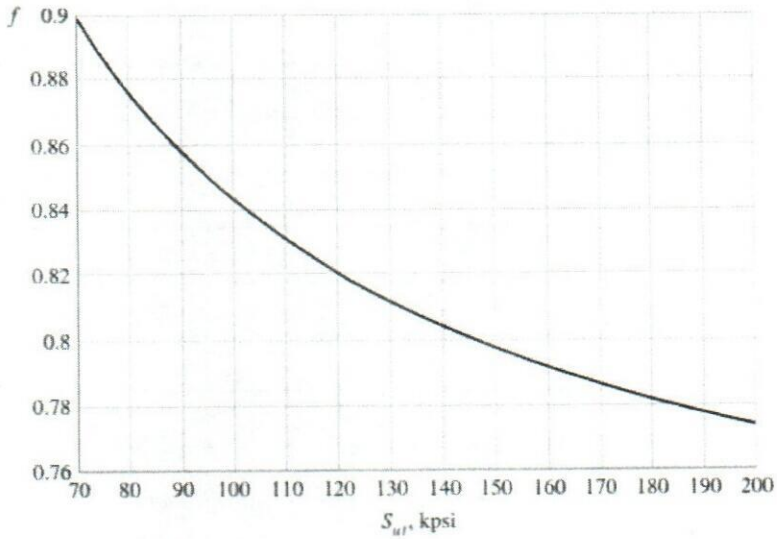


Figure 6–18

Fatigue strength fraction, f, of S_{ut} at 10^3 cycles for $S_e = S'_e = 0.5S_{ut}$ at 10^6 cycles.



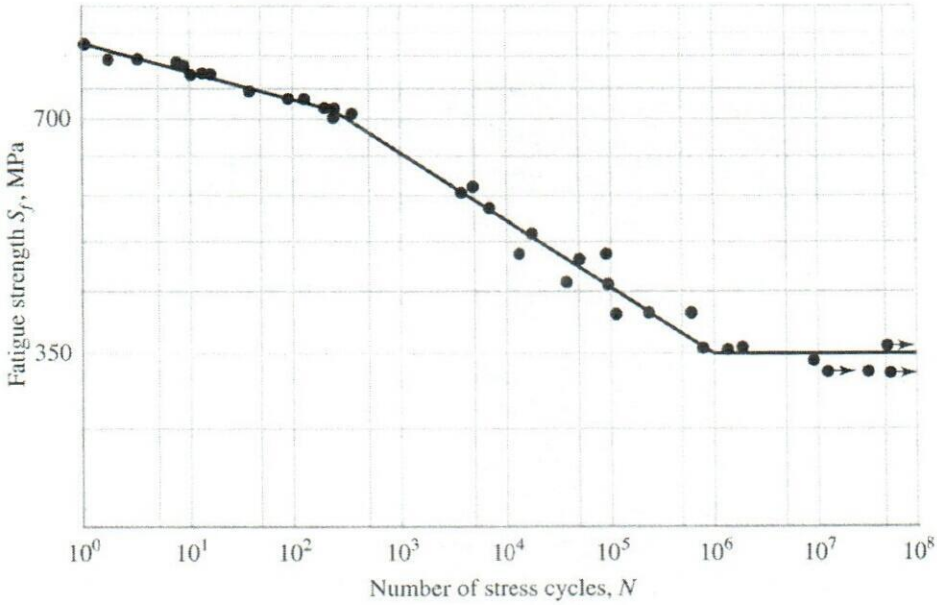
1kpsi = 6.89476 MPa

Table A–20

Deterministic ASTM Minimum Tensile and Yield Strengths for Some Hot-Rolled (HR) and Cold-Drawn (CD) Steels [The strengths listed are estimated ASTM minimum values in the size range 18 to 32 mm ($\frac{3}{4}$ to $1\frac{1}{4}$ in). These strengths are suitable for use with the design factor defined in Sec. 1–10, provided the materials conform to ASTM A6 or A568 requirements or are required in the purchase specifications. Remember that a numbering system is not a specification.] *Source:* 1986 SAE Handbook, p. 2.15.

1 UNS No.	2 SAE and/or AISI No.	3 Processing	4 Tensile Strength, MPa (kpsi)	5 Yield Strength, MPa (kpsi)	6 Elongation in 2 in, %	7 Reduction in Area, %	8 Brinell Hardness
G10060	1006	HR	300 (43)	170 (24)	30	55	86
		CD	330 (48)	280 (41)	20	45	95
G10100	1010	HR	320 (47)	180 (26)	28	50	95
		CD	370 (53)	300 (44)	20	40	105
G10150	1015	HR	340 (50)	190 (27.5)	28	50	101
		CD	390 (56)	320 (47)	18	40	111
G10180	1018	HR	400 (58)	220 (32)	25	50	116
		CD	440 (64)	370 (54)	15	40	126
G10200	1020	HR	380 (55)	210 (30)	25	50	111
		CD	470 (68)	390 (57)	15	40	131
G10300	1030	HR	470 (68)	260 (37.5)	20	42	137
		CD	520 (76)	440 (64)	12	35	149
G10350	1035	HR	500 (72)	270 (39.5)	18	40	143
		CD	550 (80)	460 (67)	12	35	163
G10400	1040	HR	520 (76)	290 (42)	18	40	149
		CD	590 (85)	490 (71)	12	35	170
G10450	1045	HR	570 (82)	310 (45)	16	40	163
		CD	630 (91)	530 (77)	12	35	179
G10500	1050	HR	620 (90)	340 (49.5)	15	35	179
		CD	690 (100)	580 (84)	10	30	197
G10600	1060	HR	680 (98)	370 (54)	12	30	201
G10800	1080	HR	770 (112)	420 (61.5)	10	25	229
G10950	1095	HR	830 (120)	460 (66)	10	25	248

Answer sheet for Q1(i) **Index Number.....**



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Beyond A Graduate

Faculty of Engineering & Technology

Department of Mechanical & Automotive Engineering

BSc Hons (Eng) Mechanical Engineering

Semester 7 Re Sit- Final Examination 2024

Module Code	:	**ME4314**
Module Title	:	**Automotive System Design**
Date	:	**8th May 2025**
Examiners	:	**S D R Perera**
Time Allowed	:	**(09 00 am – 12.00 noon)- 3 hrs**

Instructions to Candidates:

- This is a **closed** book examination.
- This paper consists of Five (05) questions. Answer **all five** questions.
- Use only the answers booklet, additional papers and graph paper for your answers.
- Write clearly and legibly with a blue or black pen.
- Write your name and student number on all sheets.
- Answers to different parts of the same question (other than any graph sheets used) should not be scattered.
- Marks will be deducted for missing or incorrect measuring units.
- You are advised to make a clear diagram for each question, where appropriate. This will help you to perform calculations correctly.
- If you have any doubt regarding the interpretation of the wording of a question, make your own assumptions and clearly state it on the answer script.

Question 01: (20 marks)

A passenger car of weight 14322 N is slowed uniformly from 86.5 km/h to 48 km/h in a distance of 152 m while running down an incline of 1 in 15.

a) Calculate the amount of heat generated in kJ during this operation
b) If the front wheels share 55% of the braking forces, calculate the mean lining pressure in N/m^2 on the front wheel brakes

Data

Brake lining width	=0.05m
Effective wheel diameter	=0.686m
Brake drum diameter	=0.318m
Lining area per drum	=0.0321m2
Coefficient of friction between drum and lining	= 0.35

Question 02 (20 marks)

(b) The following parameters are given for a typical gasoline engine

- Volumetric efficiency – 80%
- Mechanical efficiency – 70%
- Calorific value of gasoline – 42 MJ/kg
- Excess air factor – 15%
- Pressure of the mixture at the end of suction stroke – $8.24x10^4$ N/m^2.
- Temperature of the mixture at the end of suction stroke – 333K.
- Gas constant for air – 0.287 kJ/kgK
- Stoichiometric air/fuel ratio – 14.7:1

Find the cylinder dimensions for a six cylinder four stroke engine if the engine is to develop80 kW at 3800 rev/min. Assume that the S/B = 1.05, thermal efficiency is 28%, density of petrol vapor in the mixture is twice that of air.

Question 03 (20 marks)

If the crank radius and the length of connecting rod are 80 mm and 120 mm long respectively and the crank rotates at a constant speed of 2000 rpm determine

1. the crank angle at which the maximum velocity occurs
2. maximum velocity of piston

Question 04 (20 marks)

A car of mass of 300 kg, having spring of stiffness 40,000 N/m and a damper of unknown damping coefficient, is observed to vibrate with a 10 mm amplitude while the road excitation vibration has a maximum amplitude of only 2.5 mm. (at resonance). Calculate the damping constant and the amplitude of the force applying from the road surface

Question 05 (20 marks)

A single plate clutch having a single driving plate with contact surfaces on each side is required to transmit 45 kW at 6500 r.p.m. The ratio of inner radius to outer radius 0.8 the coefficient of friction is 0.4. Assuming a uniform pressure of 0.21 N/mm^2 design the clutch with a single disc having contact surfaces on either side.

END.

Data Sheet

1. The thickness of a cylinder wall

The thickness of a cylinder wall (t) is usually obtained by using a thin cylindrical formula, i.e.

$$t = \frac{p \times D}{2\sigma_c} + C$$

where

p = Maximum pressure inside the cylinder in N/mm^2,
D = Inside diameter of the cylinder or cylinder bore in mm,
σ_c = Permissible circumferential or hoop stress for the cylinder material in MPa or N/mm^2.
C = Allowance for re-boring.

The allowance for re-boring (C) depending upon the cylinder bore (D) for I. C. engines is given in the following table:

D (mm)	75	100	150	200	250	300	350	400	450	500
C (mm)	1.5	2.4	4.0	6.3	8.0	9.5	11.0	12.5	12.5	12.5

2. *Design of Cylinder Head*

The cylinder head may be approximately taken as a flat circular plate whose thickness (t_h) may be determined from the following relation:

$$t_h = D\sqrt{\frac{C.p}{\sigma_c}}$$

where

D – Cylinder bore in mm,
p - Maximum pressure inside the cylinder in N/mm^2,
σ_c - Allowable circumferential stress in MPa or N/mm^2.
C - Constant whose value is taken as 0.1.

3. The thickness of the piston head for strength

The thickness of the piston head (t_H), according to Grashoff's formula is given by

$$t_H = \sqrt{\frac{3p.D^2}{16\sigma_t}} (\text{in mm})$$

Where,

p = Maximum gas pressure or explosion pressure in N/mm^2,
D = Cylinder bore or outside diameter of the piston in mm, and
σ_t = Permissible tensile stress for the material of the piston in MPa or N/mm^2

Design of piston head for heat transfer

On the basis of second consideration of heat transfer,

$$H = \frac{K_1 \times C \times W \times BP}{A}$$

$$t_H = \frac{H}{12.56k(T_C - T_E)} (\text{in mm})$$

A = Cross sectional area in **mm^2**
K_1 = A constant representing the amount of heat absorbed by the piston = 0.5
K = Heat conductivity ... W-mm/m^2 ^{0}C

T_c-T_e = Difference in temperature at the center and that at the edge

Standard parameter for square hollow sections

Designation	Mass per metre	External surface area		(b-2t)	Gross section area	PROPERTIES About x-, y- and n-axis			
d b t		per m	per t	t	A_g	I_x	Z_x	Z_n	S_x
mm mm mm	kg/m	m^2/m	m^2/t		mm^2	10^6mm^4	10^3mm^3	10^3mm^3	10^3mm^3
250 x 250 x 9.0 SHS	65.9	0.961	14.6	25.8	8400	79.8	639	477	750
6.0 SHS	45.0	0.974	21.7	39.7	5730	56.2	450	330	521
200 x 200 x 9.0 SHS	51.8	0.761	14.7	20.2	6600	39.2	392	297	465
6.0 SHS	35.6	0.774	21.8	31.3	4530	28.0	280	207	327
5.0 SHS	29.9	0.779	26.0	38.0	3810	23.9	239	175	277
150 x 150 x 9.0 SHS	37.7	0.561	14.9	14.7	4800	15.4	205	159	248
6.0 SHS	26.2	0.574	22.0	23.0	3330	11.3	150	113	178
5.0 SHS	22.1	0.579	26.2	28.0	2810	9.70	129	96.1	151
125 x 125 x 9.0 SHS	30.6	0.461	15.1	11.9	3900	8.38	134	106	165
6.0 SHS	21.4	0.474	22.1	18.8	2730	6.29	101	76.5	120
5.0 SHS	18.2	0.479	26.3	23.0	2310	5.44	87.1	65.4	103
4.0 SHS	14.8	0.483	32.7	29.3	1880	4.52	72.3	53.6	84.5
100 x 100 x 9.0 SHS	23.5	0.361	15.4	9.11	3000	3.91	78.1	63.6	98.6
6.0 SHS	16.7	0.374	22.4	14.7	2130	3.04	60.7	47.1	73.5
5.0 SHS	14.2	0.379	26.6	18.0	1810	2.66	53.1	40.5	63.5
4.0 SHS	11.6	0.383	32.9	23.0	1480	2.23	44.6	33.5	52.6
3.0 SHS	8.96	0.390	43.5	31.3	1140	1.77	35.4	26.0	41.2
89 x 89 x 6.0 SHS	14.6	0.330	22.5	12.8	1870	2.06	46.2	36.3	56.6
5.0 SHS	12.5	0.334	26.7	15.8	1590	1.81	40.7	31.4	49.1

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CINEC Campus

Faculty of Engineering & Technology

Department of Mechanical Engineering

First Year Semester 2 Re-Sit Final Examination 2025

Module Code	:	**ME 1324**
Module Title	:	**Workshop Practice**
Date/Time	:	**7th April 2025**
Examiners	:	**Virantha E.A.I**
Time Allowed	:	**3 hrs**

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- This paper consists of four questions.
- Answer All questions.
- Write clearly legibly with a blue or black pen.
- Use answer booklet and additional paper provided by the examination department.

MATERIALS REQURIED

- CINEC answering Booklet; Extra answering paper and graph papers if required.
- You may use a scientific calculator. This must not be programmable. This may be examined during the examination.

Q1	(a)	Explain, with the aid of sketches, orthogonal cutting operations and oblique cutting operations.	5 marks
	(b)	Derive an equation to determine the shear plane angle for orthogonal metal cutting operation. Uncut Chip length=l_1 Chip length =l_2 Rake angle=α	6 marks
	(c)	The following data relate to an orthogonal metal cutting process: Chip length obtained = 96 mm Uncut chip length = 240 mm Rake angle used = 20° Depth of cut = 0.6 mm Horizontal and vertical components of cutting force = 2400 N and 240 N respectively. Determine the following: i. Shear plane angle ii. Chip thickness iii. Friction angle iv. Shear Force.	14 marks
Q2	(a)	How is the size of a lathe machine determined?	5 marks
	(b)	Explain what the differences between a turret lathe and a center lathe are.	6 marks
	(c)	Calculate and sketch the changing gear train to cut the following screws on a lathe machine with lead screw of 4mm pitch. (Assume the lathe machine is equipped with the set of changing gears ranging from 20T to 120T in steps of 5 and 127T gear wheel) i. 0.7 mm pitch ii. 1.5 mm iii. 8 TPI pitch iv. 1/12 inch pitch	14 marks

Q3	(a) Name five cutting tool materials used for machining operations. (b) Explain how the following properties vary among the cutting tools you mentioned above. Hot- Hardness Toughness Wear resistance Chipping resistance (c) A mild steel work piece is being machined by two different tools **A** and **B** under identical machining conditions. The tool life equations for these tools are. For tool –A $VT^{0.32} = 42.5$ For tool –B $VT^{0.45} = 88.6$ Where V and T are in m/s and s respectively. Determine the cutting speed above which tool B will give better tool life.	5 marks 6 marks 14 marks
Q4	(a) Sketch the sand-casting mold and name the components. (b) With the aid of sketches explain the operation of the cupola furnace. (c) A riser in the shape of a sphere is to be designed for a sand-casting mold. The casting is a rectangular plate, with length = 200 mm, width = 100 mm, and thickness = 18 mm. If the total solidification time of the casting itself is known to be 3.5 min, determine the diameter of the riser so that it will take 25% longer for the riser to solidify.	5 marks 6 marks 14 marks

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Faculty of Engineering & Technology
Department of Mechanical and Automotive Engineering
BSc Hons (Eng) Automotive Engineering / Mechanical Engineering / Mechatronics Engineering
Semester 4 Resit Final Examination 2025

Module Code	:	**ME2325**
Module Title	:	**STRENGTH OF MATERIALS**
Date	:	**8th of March 2025**
Examiner	:	**Mr. Rashmika Wickrama**
Time Allowed	:	**3 Hours**

INSTRUCTIONS TO CANDIDATES

- This is a **closed-book** examination.
- This paper consists of **FIVE** questions. You Should Answer **ALL** the questions.
- Write clearly and legibly with a blue or black pen.
- Use only the **CINEC Answering Booklet**. Additional sheets may be requested from the invigilators.
- This paper contains 8 pages.

MATERIALS REQUIRED

- CINEC answering booklet, extra answering papers.
- You may use a scientific calculator. This must not be programmable. This may be examined during the examination.
- You may use additional data provided at the end of this examination paper (Data Sheet).

STUDENT NUMBER .....

Question 01

a) **Figure 1** shows a member that is subjected to two perpendicular direct stresses σ_1, σ_2, and a simple shear stress τ.

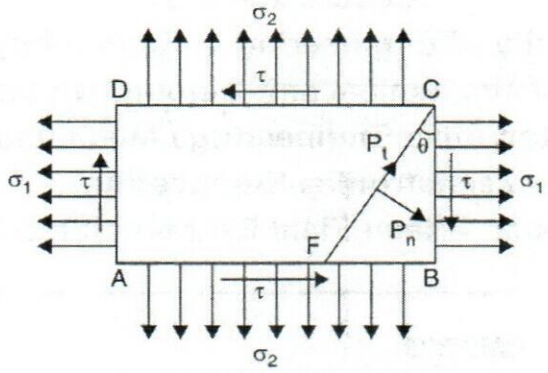


Figure 1

i. Derive the following formulas for the normal and tangential stresses of the FC plane. **40%**

$$\sigma_n = \frac{\sigma_1 + \sigma_2}{2} + \frac{\sigma_1 - \sigma_2}{2}\cos 2\theta + \tau \sin 2\theta$$

$$\sigma_t = \frac{\sigma_1 - \sigma_2}{2} \sin 2\theta - \tau \cos 2\theta$$

ii. Find the major and minor principal planes of the system. **20%**

b) As a mechanical engineering student, you are required to design a bolt made of ductile material using the theory of maximum shear stress (Tresca Criterion). The bolt is subjected to an axial tensile force of 9 kN and a transverse shear force of 4.5 kN. Given that the material's elastic limit in tension is 225 N/mm², the factor of safety (FOS) is 3, and Poisson's ratio is 0.3, determine the minimum required diameter of the bolt for safe operation. **40%**

Question 02

Consider a cast iron beam used as a structural support in an industrial workshop. The beam spans 9 m and is simply supported at both ends. Due to the installation of heavy machinery and storage racks, a uniformly distributed load of 10 kN/m acts over a specific portion of the beam's span, as shown in **Figure 2-a**. The symmetrical cross-section of the beam is shown in **Figure 2-b**.

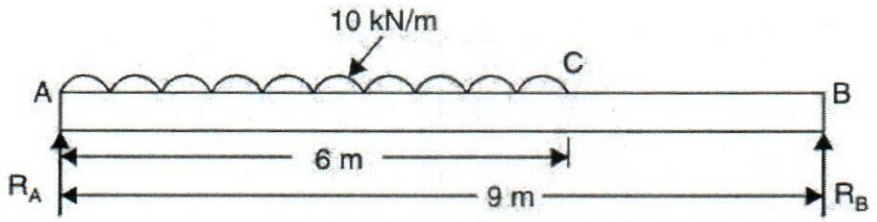


Figure 2-a

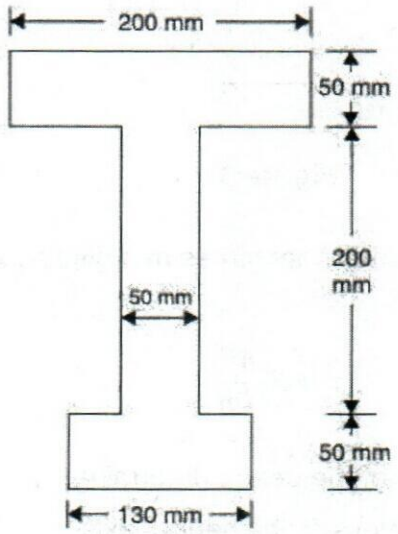


Figure2-b

i. Calculate the support reactions and draw the bending moment diagram of the beam neglecting the weight of the beam. **45%**

ii. Determine the maximum tensile and compressive stress induced in the beam. **55%**

Question 03

In the structural framework of a pedestrian bridge, a beam with an isosceles triangular cross-section is used as a support element. Due to external loading from pedestrian movement and environmental forces, the beam experiences a shear force of 30 kN at a particular section. The beam has a base width of 150 mm and a height of 450 mm as shown in **Figure 3**, making it necessary to analyse its shear stress distribution to ensure structural safety and durability.

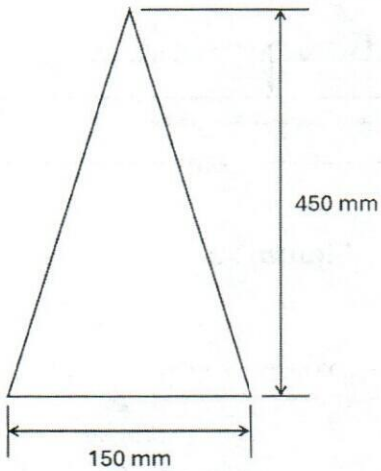


Figure 3

The following equation gives the shear stress at a distance y from the neutral axis.

$$\tau = F \frac{A \bar{y}}{I b}$$

To assess the shear capacity of the beam, determine:

i. The horizontal shear stress at the neutral axis. **40%**

ii. The distance from the top of the beam where the shear stress is maximum. **40%**

iii. The maximum shear stress within the beam. **20%**

Question 04

a) A boiler shell is subjected to an internal steam pressure of 3 N/mm². The thickness of the boilerplate is 25 mm, with a factor of safety of 3 and an ultimate tensile strength of 360 N/mm². If the efficiency of the longitudinal joint is 80% and the efficiency of the circumferential joint is 40%, determine the maximum permissible diameter of the boiler to ensure safe operation. **50%**

b) A spherical pressure vessel with a diameter of 1.5 m is subjected to an internal pressure of 2 N/mm². The maximum allowable stress in the material is 140 N/mm², and the joint efficiency is 70%. Determine the required plate thickness to ensure safe operation and the increase in the volume of the vessel due to internal pressure, given that the Poisson's ratio is 0.5 and the elastic modulus is 195 GPa. **50%**

Question 05

a) (i) An end-capped thick-walled cylinder with an internal radius of a and external radius of b is subjected to the internal pressure of P_i and external pressure of P_e. Determine the hoop stress σ_h, and radial stress σ_r, as a function of radial coordinate r using Lame's theorem. **50%**

$$\sigma_r = A - \frac{B}{r^2}$$

$$\sigma_h = A + \frac{B}{r^2}$$

(ii) Determine the axial stress σ_a for the above cylinder. **10%**

b) (i) Determine the maximum and minimum hoop stress across the section of a pipe of 400 mm internal diameter and 100 mm thick, when the pipe contains a fluid at a pressure of 7.5 N/mm².

(ii) Also, sketch the radial pressure distribution and hoop stress distribution across the section.

(iii) Determine the required minimum yield strength of the material using the maximum principal stress theory if the safety factor is 3. **40%**

Formula Sheet

Stress transformation

$$\sigma_n = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta$$

$$\tau = \frac{\sigma_x - \sigma_y}{2}\sin 2\theta - \tau_{xy}\cos 2\theta$$

Strain transformation

$$\varepsilon_n = \frac{\varepsilon_x + \varepsilon_y}{2} + \frac{\varepsilon_x - \varepsilon_y}{2}\cos 2\theta + \frac{\gamma_{xy}}{2}\sin 2\theta$$

$$\frac{\gamma}{2} = \frac{\varepsilon_x - \varepsilon_y}{2}\sin 2\theta - \frac{\gamma_{xy}}{2}\cos 2\theta$$

Principal stress and orientation

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + {\tau_{xy}}^2}$$

$$\theta_n = \frac{1}{2}\tan^{-1}\left(\frac{2\tau_{xy}}{\sigma_x - \sigma_y}\right)$$

Principal strain and orientation

$$\varepsilon_{1,2} = \frac{\varepsilon_x + \varepsilon_y}{2} \pm \sqrt{\left(\frac{\varepsilon_x - \varepsilon_y}{2}\right)^2 + \left(\frac{\gamma_{xy}}{2}\right)^2}$$

$$\theta_n = \frac{1}{2}\tan^{-1}\left(\frac{\gamma_{xy}}{\varepsilon_x - \varepsilon_y}\right)$$

Constitutive equations

$$\varepsilon_x = \frac{1}{E}\left(\sigma_x - \nu(\sigma_y + \sigma_z)\right)$$

$$\varepsilon_y = \frac{1}{E}\left(\sigma_y - \nu(\sigma_x + \sigma_z)\right)$$

$$\varepsilon_z = \frac{1}{E}\left(\sigma_z - \nu(\sigma_x + \sigma_y)\right)$$

$$\sigma_x = \frac{E}{(1+\upsilon)(1-2\upsilon)}\left[(1-\upsilon)\varepsilon_x + \upsilon(\varepsilon_y + \varepsilon_z)\right]$$

$$\sigma_y = \frac{E}{(1+\upsilon)(1-2\upsilon)}\left[(1-\upsilon)\varepsilon_y + \upsilon(\varepsilon_x + \varepsilon_z)\right]$$

$$\sigma_z = \frac{E}{(1+\upsilon)(1-2\upsilon)}\left[(1-\upsilon)\varepsilon_z + \upsilon(\varepsilon_x + \varepsilon_y)\right]$$

Relationship between elastic constants

$$G = \frac{E}{2(1+\nu)}$$

$$K = \frac{E}{3(1-2\nu)}$$

Flexure formula and shear formula for beams

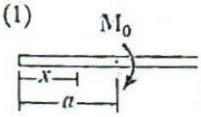
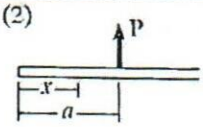
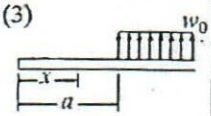
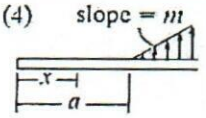
$$\sigma = -\frac{My}{I}$$

$$\tau = V\frac{A'\bar{y}'}{It}$$

Bending moment function for beams

$$M(x) = EI\frac{d^2v}{dx^2}$$

Discontinuity functions for beams

Loading	Loading Function $w = w(x)$	Shear $V = \int w(x)dx$	Moment $M = \int Vdx$
(1) 	$w = M_0\langle x-a\rangle^{-2}$	$V = M_0\langle x-a\rangle^{-1}$	$M = M_0\langle x-a\rangle^{0}$
(2) 	$w = P\langle x-a\rangle^{-1}$	$V = P\langle x-a\rangle^{0}$	$M = P\langle x-a\rangle^{1}$
(3) 	$w = w_0\langle x-a\rangle^{0}$	$V = w_0\langle x-a\rangle^{1}$	$M = \frac{w_0}{2}\langle x-a\rangle^{2}$
(4) 	$w = m\langle x-a\rangle^{1}$	$V = \frac{m}{2}\langle x-a\rangle^{2}$	$M = \frac{m}{6}\langle x-a\rangle^{3}$

Torsion equation

$$\frac{T}{J} = \frac{\phi G}{L} = \frac{\tau}{\rho}$$

Euler's buckling equation

$$P_{cr} = \frac{\pi^2 EI}{(L_e)^2}$$

Lamé's equations

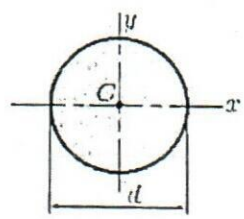
$$\sigma_r = A - \frac{B}{r^2}$$
$$\sigma_h = A + \frac{B}{r^2}$$

von Mises equivalent stress

$$\sigma_e = \frac{1}{\sqrt{2}}[(\sigma_1 - \sigma_2)^2 + (\sigma_1 - \sigma_3)^2 + (\sigma_2 - \sigma_3)^2]^{\frac{1}{2}}$$

Geometric properties of a circular area

$$I_{xx} = I_{yy} = \frac{\pi d^4}{64}$$
$$J_C = \frac{\pi d^4}{32}$$

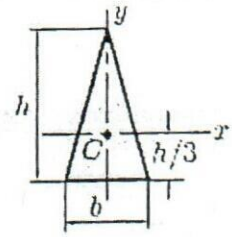


Geometric properties of a triangular area

$$I_{xx} = \frac{bh^3}{36}$$

$$I_{yy} = \frac{b^3 h}{36}$$

$$J_c = \frac{bh}{36}(b^2 + h^2)$$



Stresses induced in thin cylinders

Hoop stress $\sigma_1 = \frac{p\,d}{2\,t\,\eta_l}$

Longitudinal stress $\sigma_2 = \frac{p\,d}{4\,t\eta_c}$

Stress-induced in thin spherical cells

$$\sigma_1 = \frac{p\,d}{4\,t}$$

Volumetric Strain in thin spherical cells

$$Volumetric\ Strain = \frac{3pd}{4Et}\,[1 - \nu]$$

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Semester 4 Re-Sit Examination 2024

Module Code	:	**ME2324**
Module Title	:	**AUTOMOBILE TECHNOLOGY II**
Date	:	**06TH OF MARCH 2025**
Examiners	:	**WASABHA Y SAMARATHUNGA**
Time Allowed	:	**03 hrs.**

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(01.) Describe the construction and operating principle of transmission systems in automobiles.

A. Refer the Figure 01. 25%

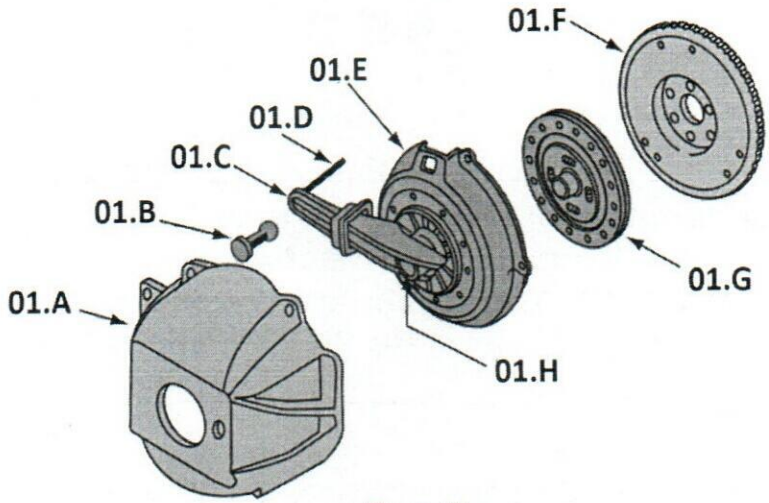


Figure 01

i.	List three functions of the component identified as 01.F of Figure 01.	15%
ii.	List two functions of the cushioning springs identified as 01.G embedded into the component 01. F.	10%

B. Refer to Figure 02 and answer the following questions. 25%

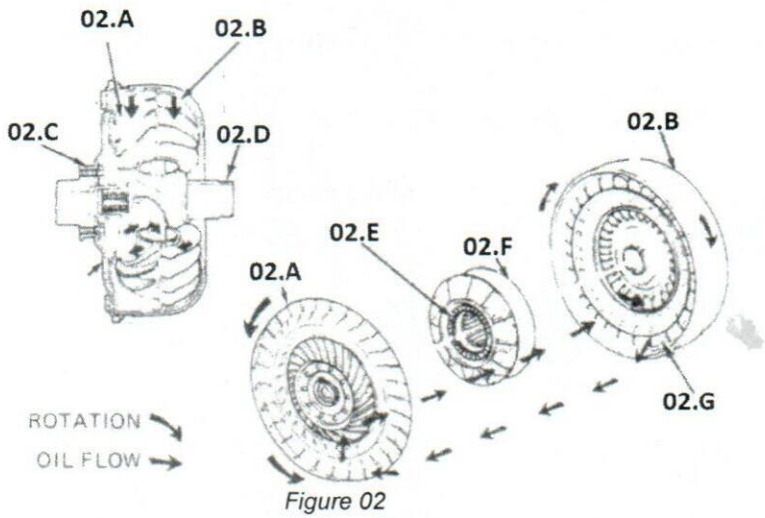


Figure 02

i.	Name the components identified as 02.A, 02.B, ...02.G of the figure 02.	12%
ii.	Explain briefly the working principle of the assembly of the components shown in the figure 02.	8%
iii.	What is the major function of the component identified as 02.F shown in the figure 02.	5%

	C.	Refer to Figure 03 and answer the following questions.		25%

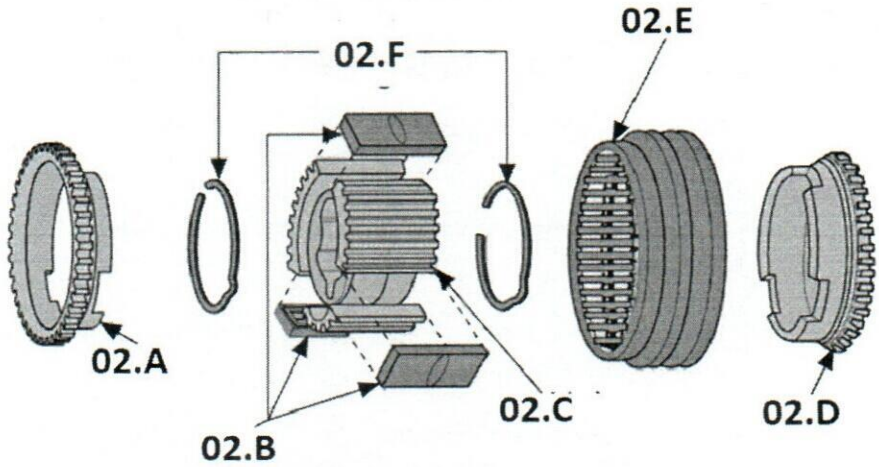


Figure 03

	i.	State two functions served by the unit when it is assembled with the components shown in Figure 03.	10%
	ii.	"Imagine a hypothetical situation, where you are driving a vehicle with a manual transmission, or a transaxle, and you are shifting from First Gear to Second Gear." Explain the mechanism of shifting the gear from First to Second. Refer to the assembled unit of the components appeared in Figure 03.	15%

	D.	Figure 04 shows a typical arrangement of wheels an automatic gearbox.	25%

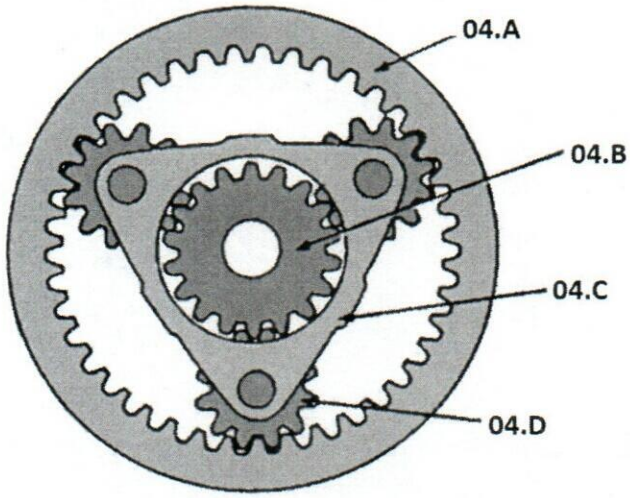


Figure 04

	i.	Explain the different engagement configurations of wheels and the outcome of each engagement	15%
	ii.	List the three components, which are used to control the wheel sets for different engagements.	10%

(02.)	Describe the construction and operating principle of suspension systems in automobiles.				
	A.	i.	List five purposes of suspension systems of vehicles.	10%	25%
		ii.	List two main types of Vehicle Body Constructions.	5%	
		iii.	Compare and contrast the two main types of constructions stated above.	10%	
	B.	i	What is the major role of the coil spring in an automotive suspension system?	6%	25%
		ii	List the four main types of suspension springs available in the automobile industry.	4%	
		iii.	Define spring rate. Explain how the spring rate plays a major role in the suspension system of an automobile.	15%	
	C.	Refer to Figure 05 and answer the questions that follow.			25%

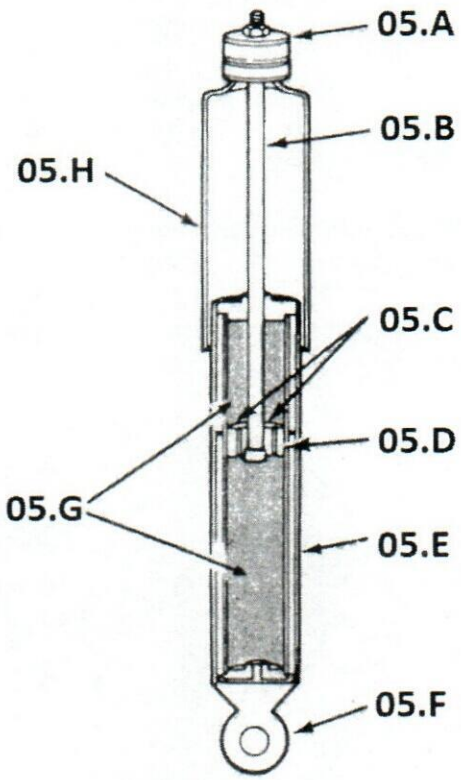


Figure 05

i.	Name the components of the assembly, which are identified as 05.A, 05.B, 05.C,.....05.H.	14%	
ii.	Explain the working mechanism of the assembly shown in the figure 05.	6%	
iii.	Comment on the following statement. "A passenger car with normal suspension requirements uses shock absorbers with a Ratio valued at 50/50."	5%	

	D.	Refer to Figure 06 and answer the questions that follow.	25%

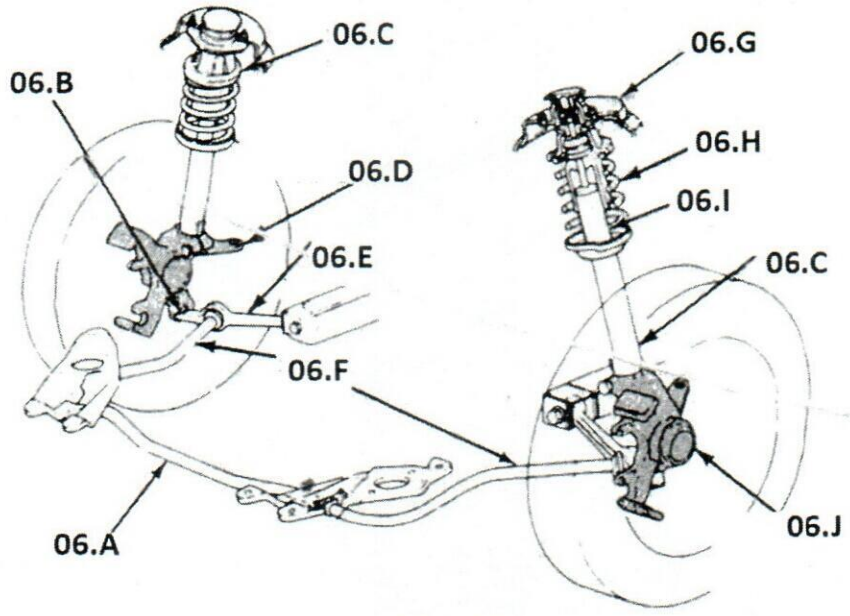


Figure 06

i.	Identify the components (06.A, 06.B, ...06.J) shown in the figure.	20%
ii.	State the main function of the component identified by 06.A.	5%

(03.) Describe the construction and operating principle of braking and steering systems in automobiles.

A. Refer to Figure 07, which illustrates a steering mechanism and answer the questions that follow. 25%

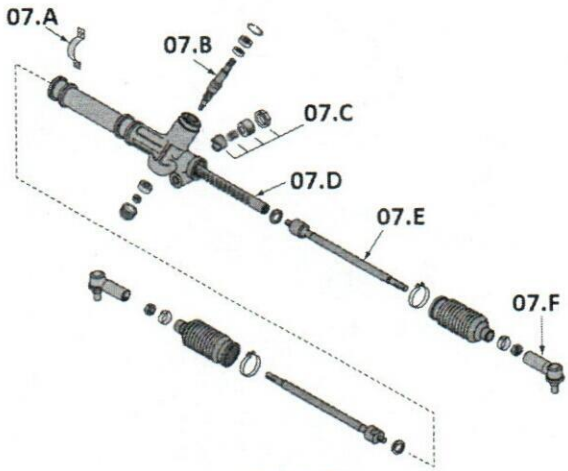


Figure 7

i.	Name the component identified as 07.D in the figure. What is **its** function and how does **it** work?	8%
ii.	Explain the purpose of the components identified as 07. C.	8%
iii.	Explain briefly how suspension geometry is adjusted by using the components 07.E and 07. F.	4%
iv.	What is the deference that can be observed when the steering system shown in the figure 07 is compared with the Parallelogram Steering System (not shown)?	5%

B. 25%

i.	Discuss briefly the purpose of the steering system and how the transmission of driver's hand movement is converted to steering action.	10%
ii.	Identify and name the angle described in the Figure 8, which controls the alignment of the wheel. Write a brief note covering the definition of this angle, and its orientation. How does it effect on the performance of the vehicle. Explain clearly, as to how if this angle is corrected if it changes from that specified by the manufacturer.	15%

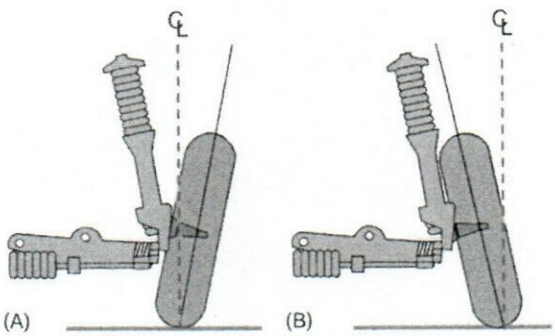
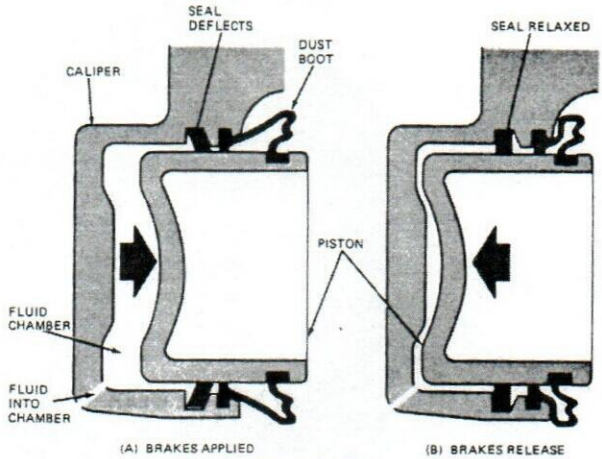
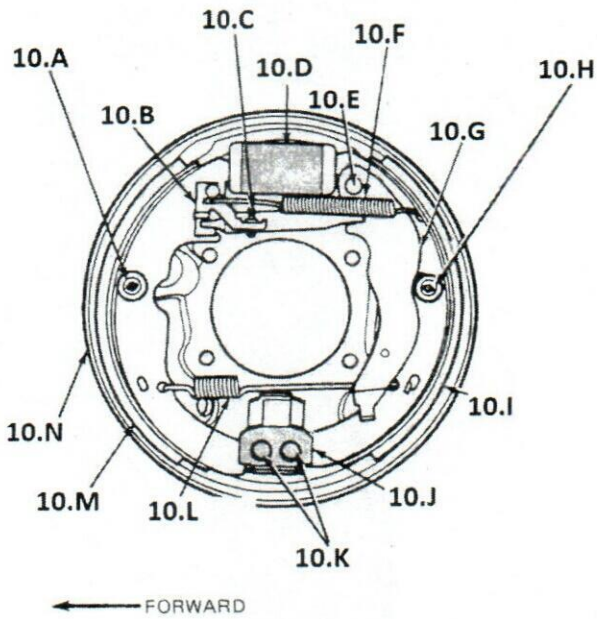


Figure 8

	C.	i.	What are the two types of "Splits" in hydraulic braking systems?	5%	26%
		ii.	Why are the Hydraulic Braking divided into two systems? Justify your answer with reasons.	7.5%	
		iii	Refer to Figure 09 and explain working relationship of the Piston and Main Oil Seal of the disk brake systems.  *Figure 09*	6%	
		iv.	Explain how the self-adjustment action takes place in the brake system as shown in the same figure 09.	7.5%	
	D.	Refer to Figure 10 and answer the question that follows.  *Figure 10*			24%
		i.	Name the components identified as 10.A, 10.B, ...10.N in the figure 10.	24%	

(04.) Describe the construction and operating principle of tyres for automobiles & describe the construction and operating principle of suspension systems in automobiles.

A. Refer to Figure 11 and answer the question below. 25%

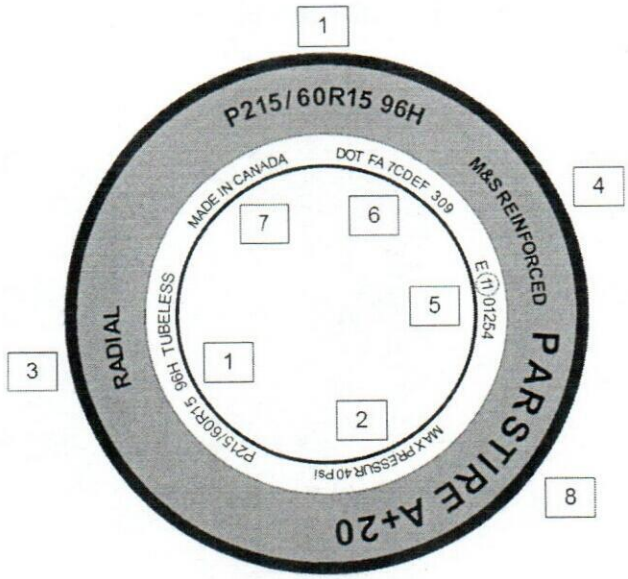


Figure 11

i.	What does each information identified as 1, 2,.....8 on the sidewall of the tire define?	16%
ii.	P 205 / 60 R 15 is technical information printed on the sidewall of a tyre. What do "P 205 and R15" reveal?	5%
iii.	What does the term "60" of the information "P 205 / 60 R 15" reveal?	4%

B. Refer to Figure 12 and answer the questions I, ii and iii that follow. 25%

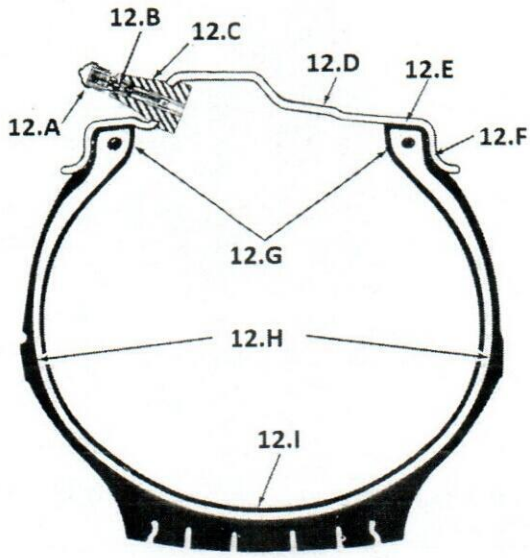
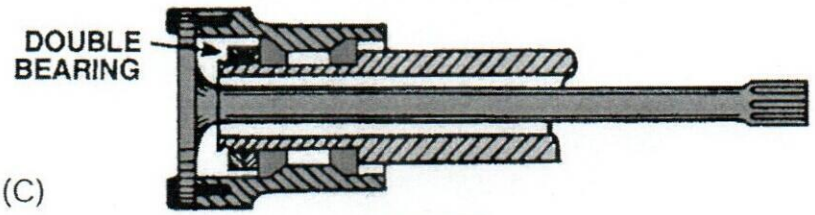
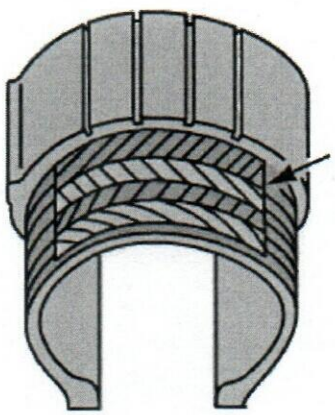


Figure 12

		i.	Name the components identified as 12. A, ...12.I).	18%	
		ii.	Explain how air is trapped inside the tyre using the component 12.B in the figure.	2%	
		iii.	What is the main function of the component, 12.G shown in the figure?	5%	
	C.	i.	In FWD vehicles, two CV joints are used on each half shaft. The joint closer to the transaxle is called the inner (or inboard) joint, while the one closer to the wheel is the outer (or outboard) joint. What are the alternative names for the two types of CV joints.	5%	25%
		ii.	State the main difference between the two CV joints mentioned above	7.5%	
		iii.	What is the type of drive axle depicted by Figure 13?  *Figure 13*	5%	
		iv.	Explain the operation of the drive axle in the same figure.	7.5%	
	D.	Refer the Figure 14.  *Figure 14*			25%
		i.	What is the type of tyre shown in the figure?	2.5%	
		ii.	What is the difference in construction of the tyre shown in the figure from other types of tyres.	5%	
		iii.	Explain the two main advantages of the type of tyre shown in the figure.	10%	
		iv.	"Maintaining proper tyre inflation is essential for extending tyre life, enhancing riding comfort, improving handling stability, and maximizing fuel efficiency." Do you agree? Justify your answer.	7.5%	

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(01.) Describe the construction and operating principle of transmission systems in automobiles.

A. Refer the Figure 01. 25%

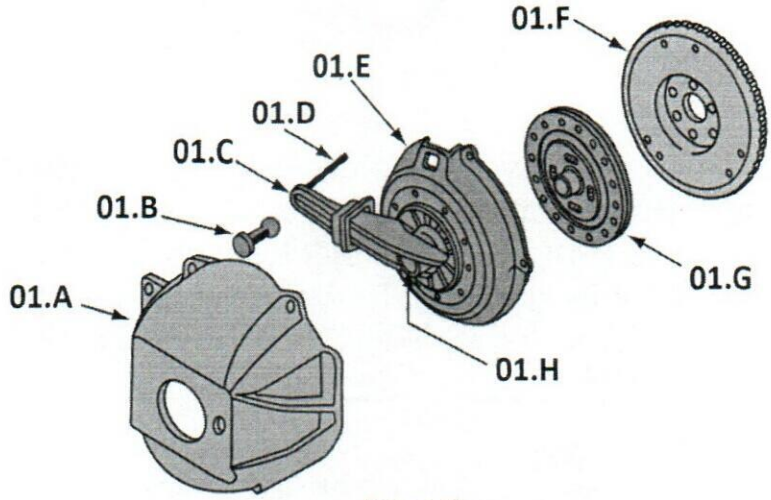


Figure 01

i.	List three functions of the component identified as 01.F of Figure 01.	15%
ii.	List two functions of the cushioning springs identified as 01.G embedded into the component 01. F.	10%

B. Refer to Figure 02 and answer the following questions. 25%

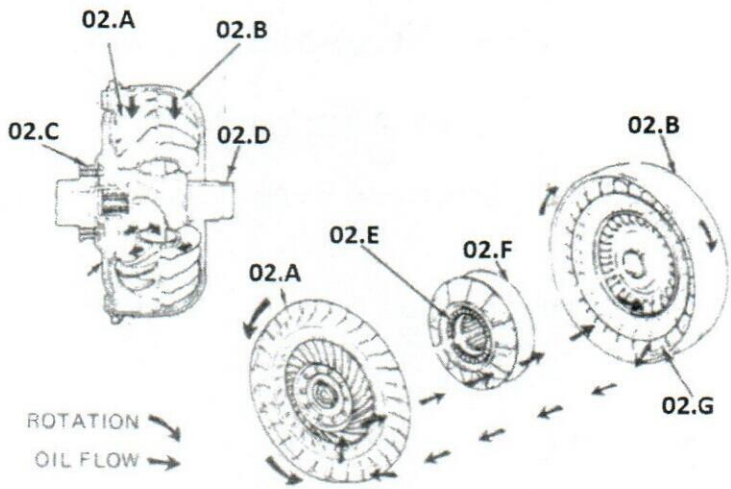


Figure 02

i.	Name the components identified as 02.A, 02.B, ...02.G of the figure 02.	12%
ii.	Explain briefly the working principle of the assembly of the components shown in the figure 02.	8%
iii.	What is the major function of the component identified as 02.F shown in the figure 02.	5%

	C.	Refer to Figure 03 and answer the following questions.		25%

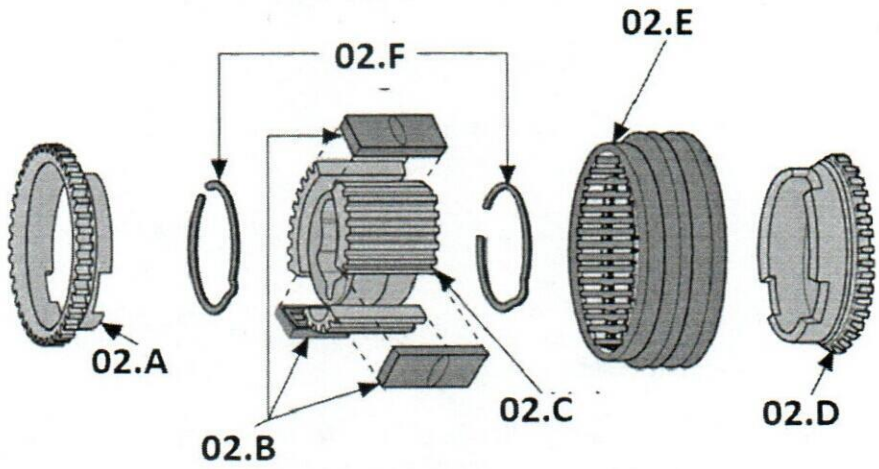


Figure 03

i.	State two functions served by the unit when it is assembled with the components shown in Figure 03.	10%	
ii.	"Imagine a hypothetical situation, where you are driving a vehicle with a manual transmission, or a transaxle, and you are shifting from First Gear to Second Gear." Explain the mechanism of shifting the gear from First to Second. Refer to the assembled unit of the components appeared in Figure 03.	15%	

D.	Figure 04 shows a typical arrangement of wheels an automatic gearbox.		25%

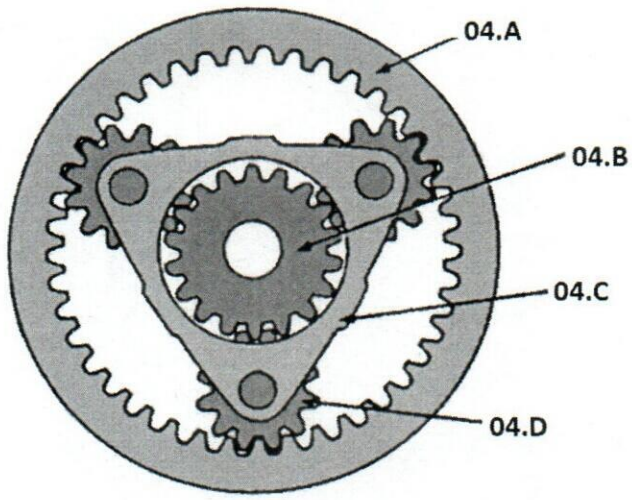


Figure 04

i.	Explain the different engagement configurations of wheels and the outcome of each engagement	15%
ii.	List the three components, which are used to control the wheel sets for different engagements.	10%

(02.)	Describe the construction and operating principle of suspension systems in automobiles.				
	A.	i.	List five purposes of suspension systems of vehicles.	10%	25%
		ii.	List two main types of Vehicle Body Constructions.	5%	
		iii.	Compare and contrast the two main types of constructions stated above.	10%	
	B.	i	What is the major role of the coil spring in an automotive suspension system?	6%	25%
		ii	List the four main types of suspension springs available in the automobile industry.	4%	
		iii.	Define spring rate. Explain how the spring rate plays a major role in the suspension system of an automobile.	15%	
	C.	Refer to Figure 05 and answer the questions that follow.			25%

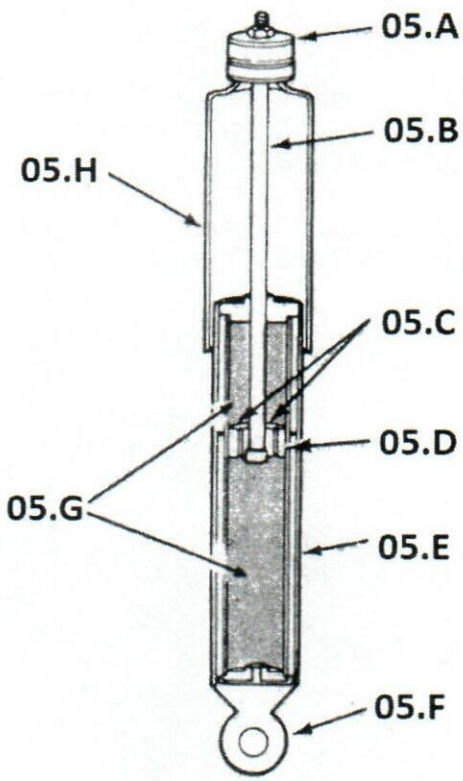


Figure 05

	i.	Name the components of the assembly, which are identified as 05.A, 05.B, 05.C,.....05.H.	14%
	ii.	Explain the working mechanism of the assembly shown in the figure 05.	6%
	iii.	Comment on the following statement. "A passenger car with normal suspension requirements uses shock absorbers with a Ratio valued at 50/50."	5%

	D.	Refer to Figure 06 and answer the questions that follow.		25%

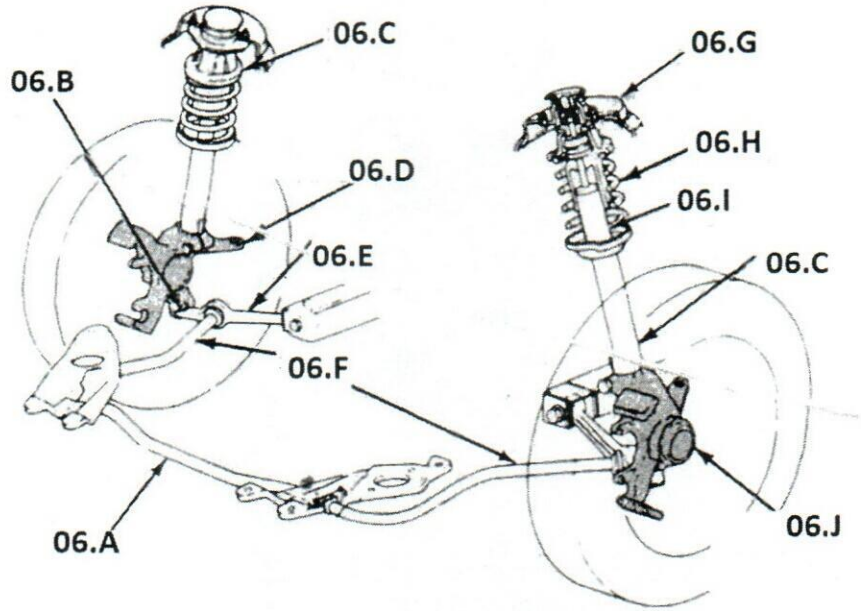


Figure 06

i.	Identify the components (06.A, 06.B, ...06.J) shown in the figure.	20%	
ii.	State the main function of the component identified by 06.A.	5%	

(03.) Describe the construction and operating principle of braking and steering systems in automobiles.

A. Refer to Figure 07, which illustrates a steering mechanism and answer the questions that follow. 25%

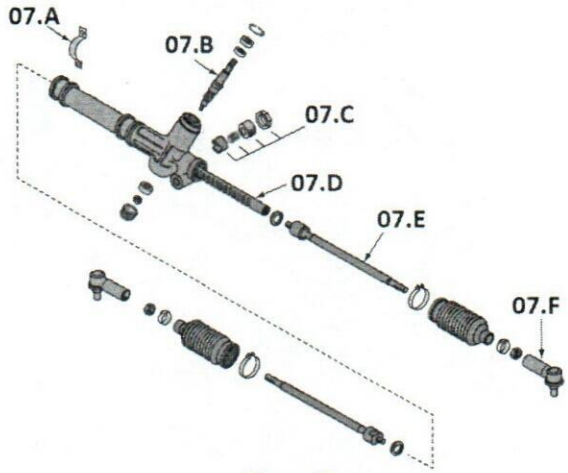


Figure 7

i.	Name the component identified as 07.D in the figure. What is **its** function and how does **it** work?	8%
ii.	Explain the purpose of the components identified as 07. C.	8%
iii.	Explain briefly how suspension geometry is adjusted by using the components 07.E and 07. F.	4%
iv.	What is the deference that can be observed when the steering system shown in the figure 07 is compared with the Parallelogram Steering System (not shown)?	5%

B.

i.	Discuss briefly the purpose of the steering system and how the transmission of driver's hand movement is converted to steering action.	10%
ii.	Identify and name the angle described in the Figure 8, which controls the alignment of the wheel. Write a brief note covering the definition of this angle, and its orientation. How does it effect on the performance of the vehicle. Explain clearly, as to how if this angle is corrected if it changes from that specified by the manufacturer.	15%

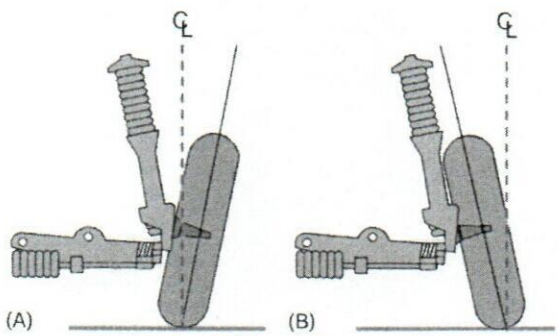
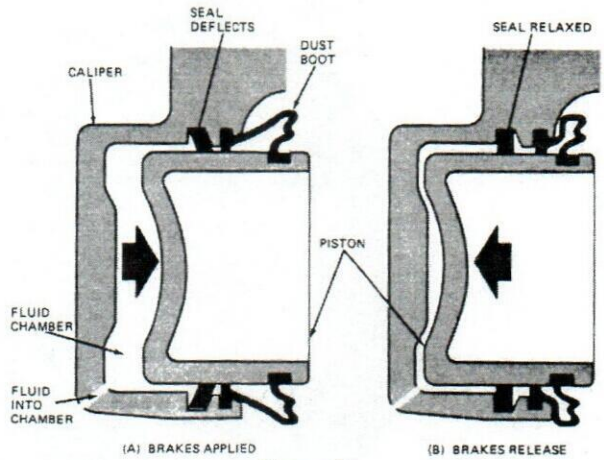
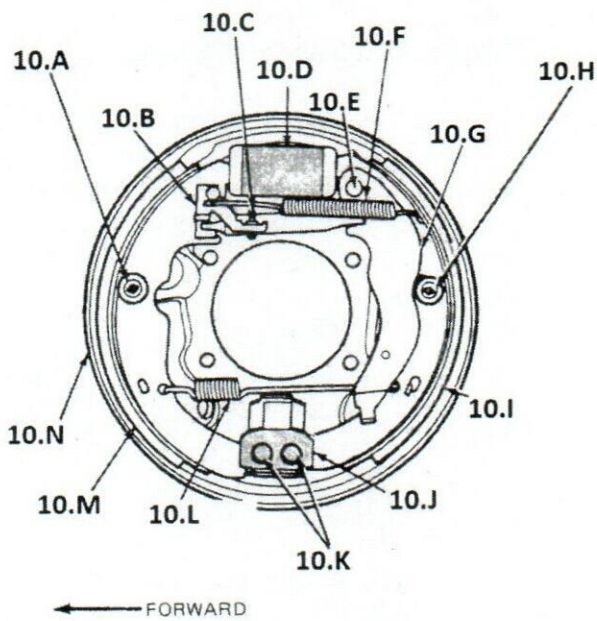


Figure 8

25%

	C.	i.	What are the two types of "Splits" in hydraulic braking systems?	5%	26%
		ii.	Why are the Hydraulic Braking divided into two systems? Justify your answer with reasons.	7.5%	
		iii	Refer to Figure 09 and explain working relationship of the Piston and Main Oil Seal of the disk brake systems.  *Figure 09*	6%	
		iv.	Explain how the self-adjustment action takes place in the brake system as shown in the same figure 09.	7.5%	
	D.	Refer to Figure 10 and answer the question that follows.  *Figure 10*			24%
		i.	Name the components identified as 10.A, 10.B, ...10.N in the figure 10.	24%	

(04.) Describe the construction and operating principle of tyres for automobiles & describe the construction and operating principle of suspension systems in automobiles.

A. Refer to Figure 11 and answer the question below. 25%

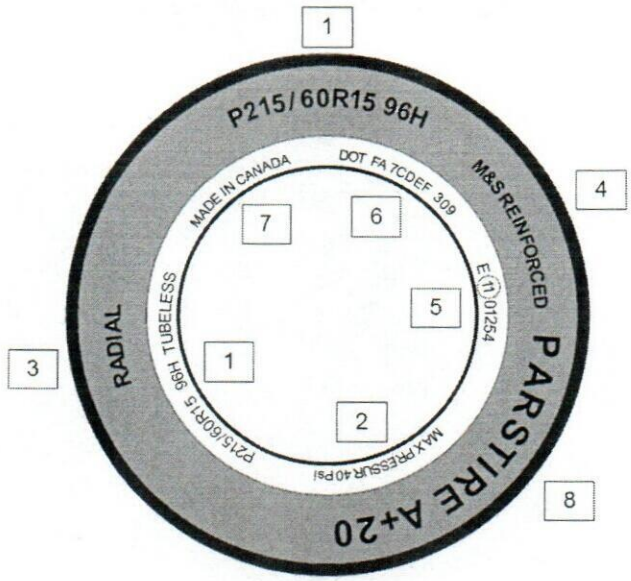


Figure 11

i. What does each information identified as 1, 2,.....8 on the sidewall of the tire define? 16%

ii. P 205 / 60 R 15 is technical information printed on the sidewall of a tyre. What do "P 205 and R15" reveal? 5%

iii. What does the term "60" of the information "P 205 / 60 R 15" reveal? 4%

B. Refer to Figure 12 and answer the questions I, ii and iii that follow. 25%

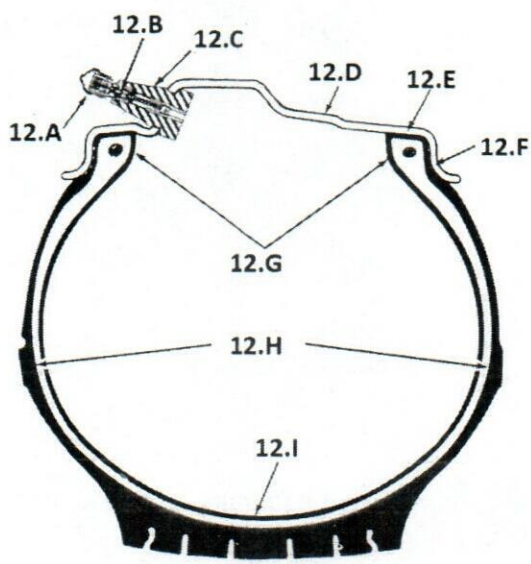
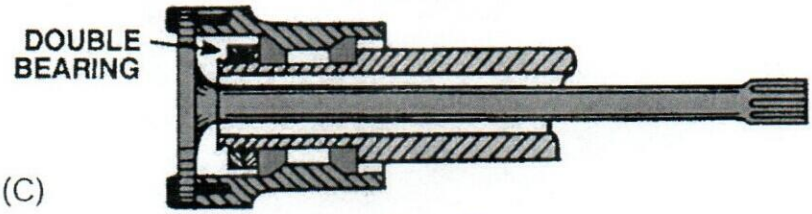
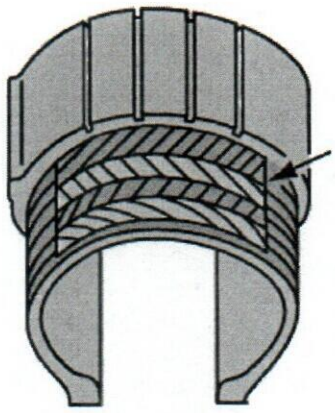


Figure 12

		i.	Name the components identified as 12. A, ...12.I).	18%	
		ii.	Explain how air is trapped inside the tyre using the component 12.B in the figure.	2%	
		iii.	What is the main function of the component, 12.G shown in the figure?	5%	
	C.	i.	In FWD vehicles, two CV joints are used on each half shaft. The joint closer to the transaxle is called the inner (or inboard) joint, while the one closer to the wheel is the outer (or outboard) joint. What are the alternative names for the two types of CV joints.	5%	25%
		ii.	State the main difference between the two CV joints mentioned above	7.5%	
		iii.	What is the type of drive axle depicted by Figure 13?  *Figure 13*	5%	
		iv.	Explain the operation of the drive axle in the same figure.	7.5%	
	D.	Refer the Figure 14.  *Figure 14*			25%
		i.	What is the type of tyre shown in the figure?	2.5%	
		ii.	What is the difference in construction of the tyre shown in the figure from other types of tyres.	5%	
		iii.	Explain the two main advantages of the type of tyre shown in the figure.	10%	
		iv.	"Maintaining proper tyre inflation is essential for extending tyre life, enhancing riding comfort, improving handling stability, and maximizing fuel efficiency." Do you agree? Justify your answer.	7.5%	

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Faculty of Engineering & Technology
Department of Mechanical & Automotive Engineering
BSc Hons (Eng) in Mechanical Engineering, BSc Hons (Eng) in Automotive Engineering & BSc Hons (Eng) in Mechatronics Engineering
Year 2 Semester 1 Resit Examination 2025

Module Code	:	**ME2323**
Module Title	:	**Dynamics of Mechanical Systems**
Date	:	**2nd March 2025 / 13.30-16.30**
Examiners	:	**Sriyarathna Peiris**
Time Allowed	:	**3 Hours**

INSTRUCTIONS TO CANDIDATES

- This paper consists of 5 questions.
- You Should Answer all questions.
- Write clearly legibly with a blue or black pen.
- Use only the **CINEC Answering Booklet**. Additional sheets may be requested from the invigilators.
- This paper contains 6 pages.

MATERIALS REQURIED

- CINEC answering Booklet; Extra answering paper
- You may use a scientific calculator. This must not be programmable. This may be examined during the examination.
- You may use additional data provided at the end of this examination paper

Q1. In an epicyclic gear of the 'sun and planet' type shown in Fig. Q1, the pitch circle diameter of the internally toothed ring is to be 224 mm and the module 4 mm. When the ring D is stationary, the spider A, which carries three planet wheels C of equal size, is to make one revolution in the same sense as the sun wheel B for every five revolutions of the driving spindle carrying the sun wheel B. Determine suitable numbers of teeth for all the wheels.

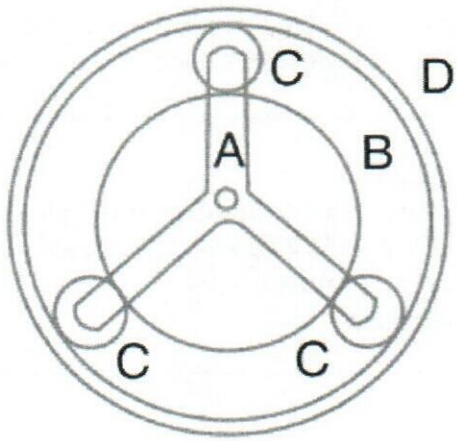


Fig Q1

(20 Marks)

Q2. A shaft fitted with a flywheel rotates at 250 r.p.m. and drives a machine. The torque of machine varies in a cyclic manner over a period of 3 revolutions. The torque rises from 750 N-m to 3000 N-m uniformly during 1/2 revolution and remains constant for the following revolution. It then falls uniformly to 750 N-m during the next 1/2 revolution and remains constant for one revolution, the cycle being repeated thereafter. Determine the power required to drive the machine and percentage fluctuation in speed, if the driving torque applied to the shaft is constant and the mass of the flywheel is 500 kg with radius of gyration of 600 mm. (20Marks)

Q3. A cantilever shaft of 75 mm diameter and 1 metre long is fixed at one end and other end carries a flywheel of mass 500 kg. Taking Young's modulus for the shaft material as 200 GN/m^2, find the frequency of longitudinal and transverse vibrations. (20 Marks)

Q4. A mass M of 70 kg is hung from a rope wrapped round a drum of effective radius of 0.25 meter, which is keyed to shaft A. Shaft A is geared to shaft B which runs at 5 times the speed of shaft A. The total mass moment of inertia of the masses attached to shaft A is 100 kg-m^2 and that of shaft B is 5 kg-m^2.

Find the acceleration of mass M if,

1. it is allowed to fall freely, and
2. when the efficiency of the gearing system is 90%.

The configuration of the system is shown in Fig. Q4.

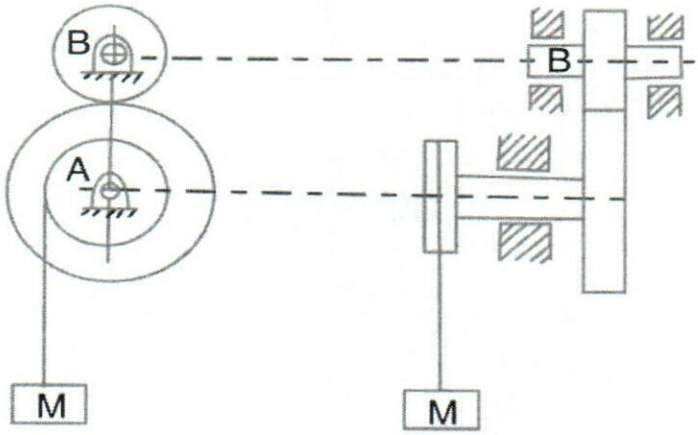


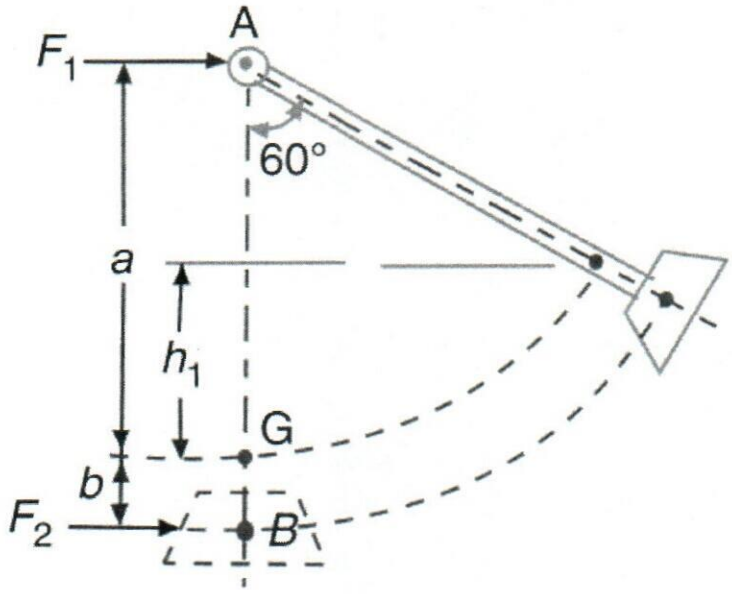
Fig Q4

(20 Marks)

Q5. The pendulum of an Izod impact testing machine shown in Fig. Q5, has a mass of 35 kg. The center of gravity of the pendulum is 0.9 m from the axis of suspension and the striking knife is 140 mm below the center of gravity. The radius of gyration about the point of suspension is 1.2 m, and about the center of gravity is 340 mm. In making a test, the pendulum is released from an angle of 60° to the vertical.

Determine:

1. striking velocity of the pendulum,
2. impulse on the pendulum and sudden change of axis reaction when a specimen gives an impact value of 54 N-m when broken.



(20 Marks)

Formula sheet

Maximum fluctuation of energy

$(\Delta E) = m.k^2.\omega^2.C_S$

Moment of inertia of the shaft it's diameter,

$$I = \frac{\pi}{64}d^4$$

Static deflection of the shaft,

$$\delta = \frac{W.l}{A.E}$$

Frequency of vibration,

$$f_n = \frac{1}{2\pi}\sqrt{\frac{9.81}{\delta}} = \frac{0.4985}{\sqrt{\delta}}\text{Hz}$$

Torque required to shaft A in order to accelerate shaft B

$T_{AB} = G.T_B = G^2.I_B.\alpha_A$

Total torque must be applied to shaft A to accelerate the geared system

$T = T_A + T_B = I_A\alpha_A + G^2.I_B.\alpha_A$

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CINEC Campus
Faculty of Engineering & Technology
Department of Electrical and electronics engineering
BSc Hons (Eng) Mechatronics Engineering
Semester 3 First Sit Final examination 2025

Module Code	:	**EE2317**
Module Title	:	**Data Structures and Soft Computing**
Date	:	**2025.02.26**
Time Allowed	:	**09:00 am – 12:00 noon**

—

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- This paper consists of 5 questions. You Should Answer **ALL** questions.
- Write clearly legibly with a blue or black pen.
- Use only the **CINEC Answering Booklet**. Additional sheets may be requested from the invigilators.
- This paper contains 4 pages.

MATERIALS REQURIED

- CINEC answering Booklet; Extra answering paper
- You may use a scientific calculator. This must not be programmable. This may be examined during the examination.

Question 1:

Arrays and Stacks are two data structures commonly used in Software systems.

(a) Explain the concept of an array as a static data structure and a stack as a dynamic data structure. (5 marks)

(b) You are tasked with designing a system to reverse a sequence of integers provided as input (e.g., [1, 2, 3, 4] becomes [4, 3, 2, 1]). Explain how you can achieve this task using

(i) Using an array

(ii) Using a stack

(2 x 5 = 10 marks)

(a) Describe two applications, except the application used in Question 1. (b), where a stack data structure is the most suitable one. (5 marks)

Question 2:

(a) Describe the structure of a singly linked list and a queue. (5 marks)

(b) Explain how a queue can be implemented using a singly linked list, focusing on the operations of enqueue (adding an element) and dequeue (removing an element). (10 marks)

(c) Discuss one advantage and one disadvantage of this implementation compared to an array-based queue. (5 marks)

Question 3:

(a) Define a binary tree and a directed graph. Explain the key differences between them in terms of structure and traversal methods. (6 marks)

(b) Discuss how Depth-First Search (DFS) can be applied to both, including one similarity and one difference in their implementation. (6 marks)

(c) You are designing a navigation system for a small city. The system uses a binary search tree (BST) to store sorted location IDs and a directed graph to represent roads between locations.

(i) Write pseudocode to insert a new location ID into the BST and maintain its sorted property. (4 marks)

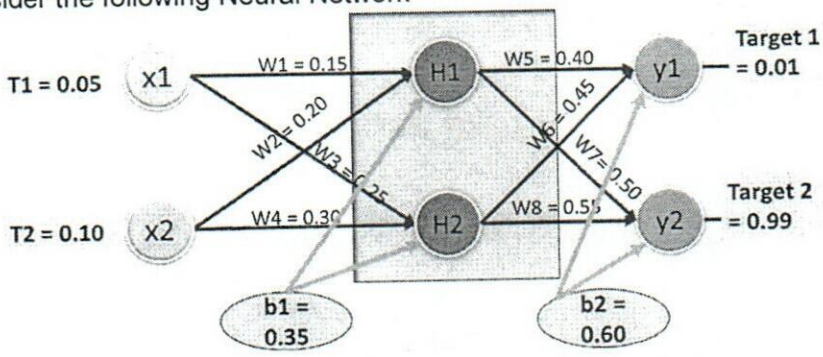
(ii) Given a directed graph with 5 nodes (A, B, C, D, E) and edges (A→B, A→C, B→D, →D, D→E), write pseudocode to perform Depth First Search starting from node A to find a path to node E. (4 marks)

Question 4

(a) Explain the following terms

(i) Backpropagation
(ii) Feed Forward Network
(iii) Hidden Layer
(iv) bias
(10 Marks)

(b) Consider the following Neural Network



Compute the outputs for neurons H1, H2, Y1 and Y2. Show all necessary steps in your calculation. (10 marks).

Question 5

You are tasked with designing a meal at a restaurant that satisfies the following criteria:

The total cost of the meal must not exceed a budget of LKR 2,000
The goal is to minimize the total caloric intake of the meal while staying within the budget.
The restaurant offers the following menu items, each with its associated cost and calorie count:

Menu Code	Item	Cost	Calories
10	Soup	400.00	200
12	Salad	500.00	150
21	Grilled Chicken	800.00	300
24	Pasta	700.00	400
33	Fruit Platter	600.00	1000
35	Watalappan	500.00	350

Each individual in the population represents a possible combination of menu items (a meal). For example, an individual might represent the combination [Salad, Grilled Chicken, Fruit Plate].

(a) What is a suitable genotype for this problem? (3 marks)

(b) Design a suitable Fitness Function for the problem (3 marks)

(c) Carry out the first iteration of the genetic algorithm for the problem.

(i) Generate a population of 4 Chromosomes

(ii) Conduct the crossover (single point crossover) of parents

(iii) Carry out the mutation

(iv) Do the selection of the next generation of population

(12 marks)

(d) Analyze the second generation of the population with the initial population in terms of their fitness. (2 marks)

----------END OF PAPER ----------

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Semester 3 Examination 2025

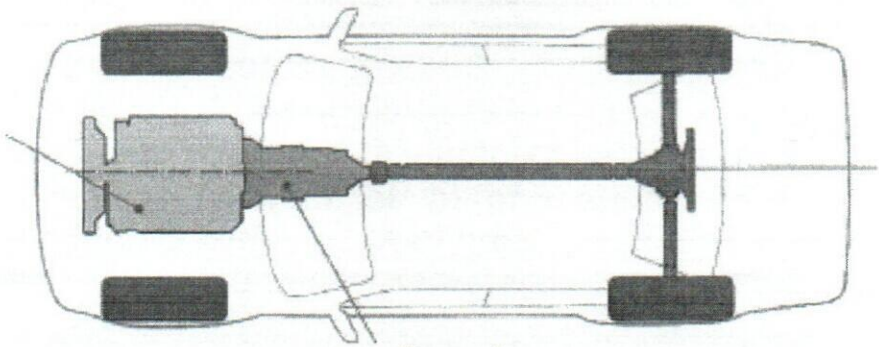
Module Code	:	**ME2316**
Module Title	:	**AUTOMOBILE TECHNOLOGY I**
Date	:	**22ND OF FEBRUARY 2025**
Examiners	:	**WASABHA Y SAMARATHUNGA**
Time Allowed	:	**03 hrs.**

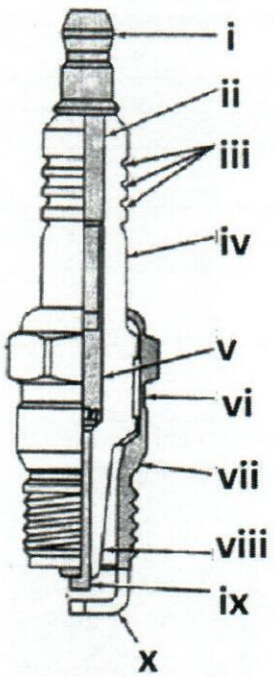
INSTRUCTIONS TO CANDIDATES

- This is a **closed-book** examination.
- This paper consists of **FOUR** questions. You Should Answer **ALL** the questions.
- Write clearly and legibly with a blue or black pen.
- Use only the **CINEC Answering Booklet**. Additional sheets may be requested from the invigilators.
- This paper contains **07** pages.

MATERIALS REQURIED

- CINEC answering Booklet; Extra answering paper & Data sheets.
- You may use a scientific calculator. This must not be programmable. This may be examined during the examination.
- You may use additional data provided at the end of this examination paper (Data Sheet).

(01.)	Explain the history, layout and configuration of automobiles & explain the provisions of the Motor Traffic Act, and the current Emission Regulations. (LO 01 & LO 02)			
	A	Examine the vehicle layout given in Figure 01 and answer the following questions.		30%
		 *Figure 1*		
		a.	What is meant by the term Layout of a vehicle?	10%
		b.	What is meant by the term Configuration of a vehicle?	10%
		c.	Identify the Layout and the Configuration of the vehicle illustrated in Figure 01.	10%
	B.	Briefly explain the following terms from the legal context.		20%
		a.	Law	10%
		b.	Act	10%
	C.	Explain the Four-Stroke Diesel Cycle of an Internal Combustion engine. Use clear sketches to support your answer.		30%
	D.	Compare and contrast two-stroke and four-stroke compression engines highlighting five differences.		20%

(02.)	Describe the construction and operating principle of, systems, sub systems and main components of an automobile. (LO 03)				
	A.	a.	List five functions of Lubricating Oils.	10%	25%
		b.	Compare the Conventional Wet Sump Setup against a Dry Sump Setup and highlight the main differences that exist between them,	7.5%	
		c.	Explain what Crankcase Ventilation means and how it is achieved in IC engines.	7.5%	
	B.	a.	Figure 2 illustrates a typical spark plug. Identify the features indicated by the arrows.  *Figure 2*	20%	30%
		b.	What is meant by the Spark Plug Reach? Explain the adverse effects of operating an IC engine with spark plugs without proper reach.	10%	
	C.	a.	Define the following terms related to engine valve operation.	15%	25%
			i. Valve Lead — 5%		
			ii. Valve Lag — 5%		
			iii. Valve Overlap — 5%		
		b.	State the three main functions of a piston.	10%	
	D.	a.	List the three types of Automotive Emission Control Systems available in an Automobile.	5%	20%
		b.	Explain the function of the Exhaust Gas Recirculation (EGR) system, with a focus on its working principle and how it operates.	15%	

(03.) Explain the different types of fuels used in SI and CI engines and the respective combustion processes. (LO 04)

A. Read and understand the Figure 03 and answer the questions. 25%

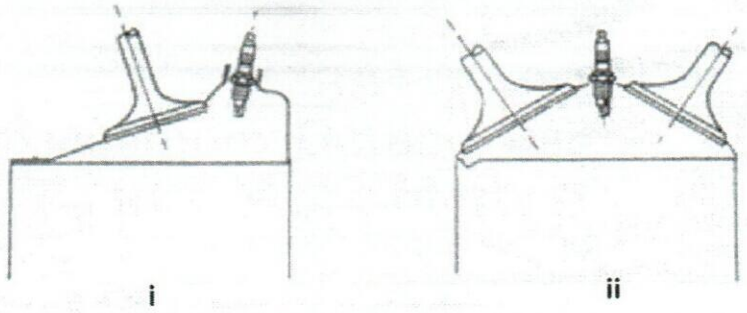


Figure 03

a.	Identify the two types of the combustion chambers illustrated in Figure 03 i and Figure 03 ii.	5%
b.	Explain the Significance of the Combustion Chamber shown in Figure 03.i.	10%
c.	Explain the Significance of the Combustion Chamber shown in Figure 3.ii.	10%

B. Figure 04 illustrates the typical Air Fuel Ratios required by a gasoline engine under different operating conditions. Examine the information given in the figure and answer the questions. 25%

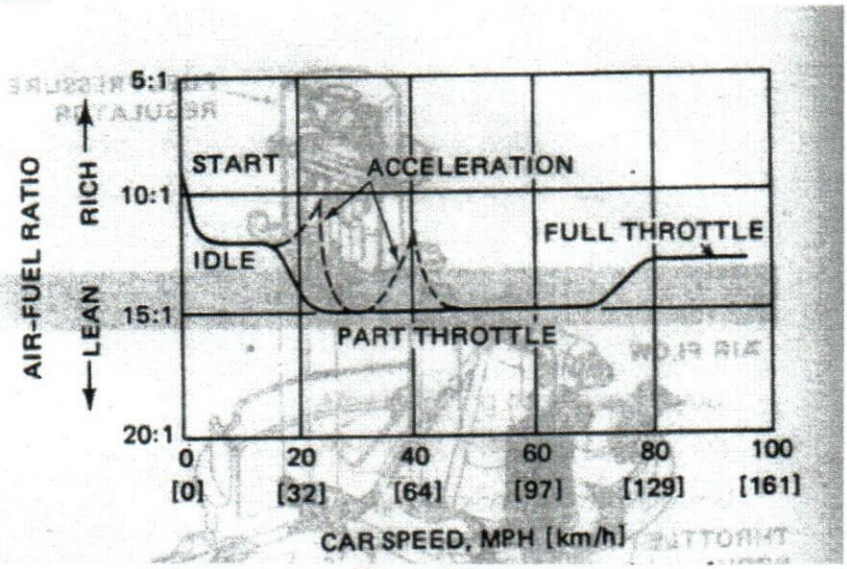
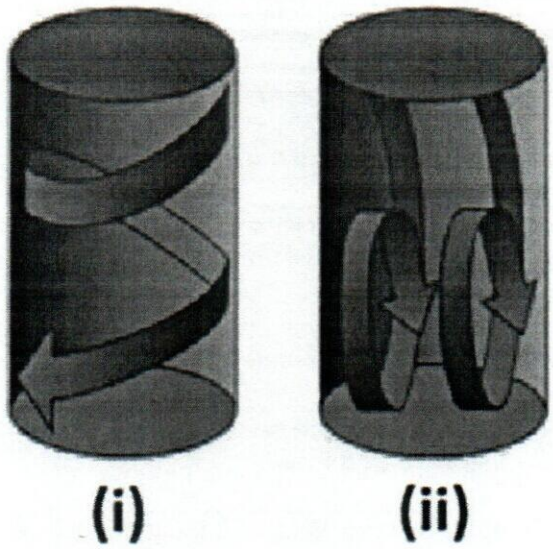


Figure 04

a.	Explain the purpose of varying the air fuel ratio as illustrated in the Figure 04.	5%
b.	"Stoichiometry is the calculation of Reactants and Products from a chemical reaction." Justify the statement. What is meant by Stoichiometric Ratio? State the characteristics of a reaction that occurs in accordance with stoichiometric principles.	10%

		c.	Explain why it is important to maintain a minimum and a maximum limit of an air fuel ratio.	10%	
	C.	a.	Define the term "Delay Period" in combustion of diesel fuel.	5%	30%
		b.	List five factors affecting the "Delay Period" in combustion of diesel fuel.	10%	
		c.	Write two short descriptions on the two types of "Delay Periods" in combustion of diesel fuel.	15%	
	D.	Understand the two different scenarios shown Figure 05 and answer the questions.			20%
			 *Figure 05*		
		a.	Identify the scenario illustrated in figure 05.i and write a short description on it including the definition, propagation, and the functions of it.	10%	
		b.	Identify the scenario illustrated in figure 05.ii and write a short description on it including the definition, propagation and propagation.	10%	

(04.) Perform calculations to determine engine performance parameters. (LO 05)

The Following is an extract from a specification sheet of a Honda K24 4 Cylinder Four-Stroke fully stock gasoline engine. Answer the following questions based on such information.

Bore Diameter	86mm
Stroke Length	99mm
Connecting Rod Length	152mm
Stock Compression	10.1:1
No of Cylinders	4
HV	46,000 kJ/kg

Table 1 - Specification Table - Honda K24 4 Cylinder Four-Stroke fully stock gasoline engine

A.	a.	Calculate the engine capacity.	10%	20%
	b.	Calculate the compression volume	10%	
B.	It was recorded that the Honda K24 4 Cylinder Four-Stroke fully stock gasoline engine is capable of producing 202.01 Nm of torque at 7,000 rpm.			40%
	a.	Calculate the Brake Power produced by the engine when it produces 202.01 Nm of Torque at 7,000 rpm.	10%	
	b.	The above gasoline engine said to have a Mechanical Efficiency of 88%. Calculate the Indicated Power.	10%	
	c.	Calculate the Indicated Mean Effective Pressure.	10%	
	d.	Calculate the Frictional Loss of the engine.	10%	
C.	a.	Calculate the average piston speed at 7,000 rpm.	10%	20%
	b.	If S = 2a, find the distances the piston travelled at the engine speed of 7,000 rpm when the crank angle is 35° passing the TDC.	10%	
D.	It was recorded that the fuel flow rate of the above gasoline engine is $0.13\ kg/min.$			20%
	a.	Calculate the Brake Specific Fuel Consumption	10%	
	b.	Calculate the Brake Thermal Efficiency	10%	

DATA SHEET

Equivalence Ratio	$\phi = \frac{A/F_{St}}{A/F}$
Lambda value(λ)	$\lambda = \frac{1}{\phi}$
Pythagorean Identity	$1 = \sin^2\theta + cos^2\theta$
The Displacement Volume	$d_p = \left(\frac{\pi}{4}\right) d^2 L$
Engine Capacity	$V_D = \left(\frac{\pi}{4}\right) B^2 S \times K = d_p \times K$
Average Piston Speed	$\overline{U_p} = \frac{2S * N}{60}$
Distance between the Wrist Pin Axis and the Main Journal Axis at a given Crank Angle	$l_{(\theta)} = acos\theta + \sqrt{r^2 - (a\sin\theta)^2}$
Brake Power	$BP = \left(\frac{2\pi TN}{60 \times 1000}\right)$
Mechanical Efficiency	$\eta_m = \frac{BP}{IP}$
Indicated Power for a Four Stroke Engine	$IP = \frac{P_i * LANK}{2 * 60{,}000}$
Frictional Power	$FP = IP - BP$
Brake Specific Fuel Consumption	$(BSFC) = \frac{60.W_f}{\mathrm{BP}}$
Fuel Flow Rate	$W_f = \frac{Amount\ of\ Fuel\ Delivered}{Time\ Period}$
Brake Thermal Efficiency	$\eta_B = \frac{60.\mathrm{BP}}{W_f.HV}$
Compression Ratio	$r = r_c = \frac{V_t}{V_c} = \frac{V_c + d_p}{V_c}$
Brake Mean Effective Pressure	$Bp = \frac{bmep * LANK}{2 * 60{,}000}$

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Department of Mechanical & Automobile Engineering
BSc Hons (Eng) In Automobile Engineering
Semester 5 Examination 2025

Module Code	:	**ME3314**
Module Title	:	**AUTOMOBILE ENGINEERING**
Date	:	**20th OF JANUARY 2025**
Examiners	:	**WASABHA Y SAMARATHUNGA**
Time Allowed	:	**03 hrs.**

INSTRUCTIONS TO CANDIDATES

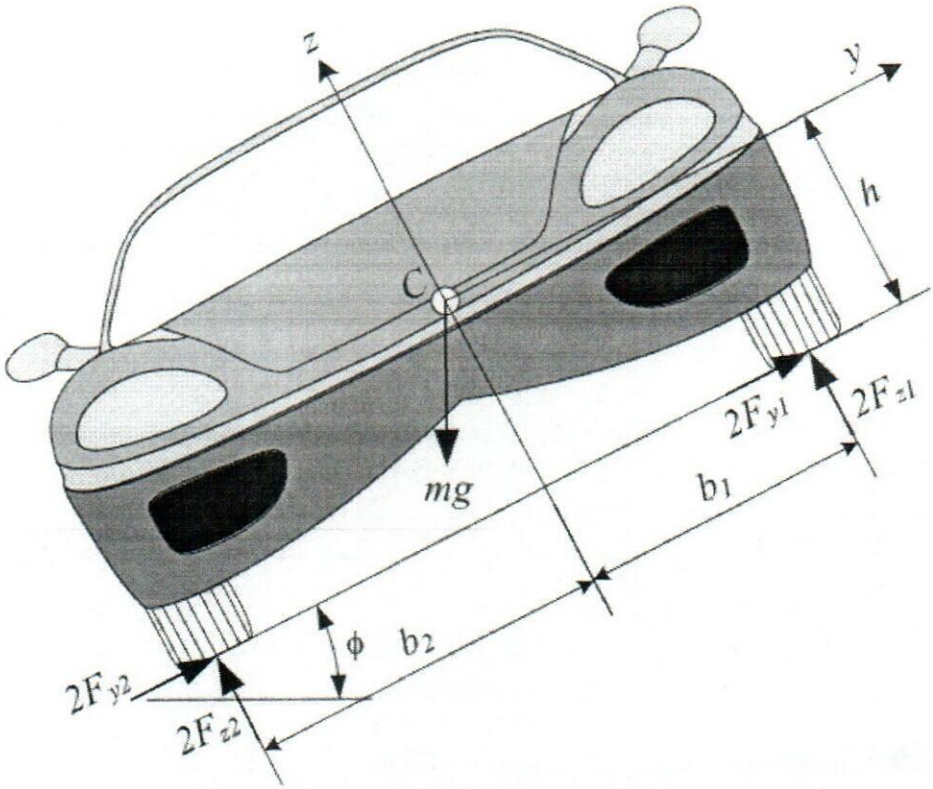
- This is a **closed-book** examination.
- This paper consists of **FOUR** questions. You Should Answer **ALL** the questions.
- Write clearly and legibly with a blue or black pen.
- Use only the **CINEC Answering Booklet**. Additional sheets may be requested from the invigilators.
- This paper contains **07** pages.

MATERIALS REQURIED

- CINEC answering Booklet; Extra answering paper & Data sheets.
- You may use a scientific calculator. This must not be programmable. This may be examined during the examination.
- You may use additional data provided at the end of this examination paper (Data Sheet).

(01.) Describe the dynamic behaviour of an automobile and determine power requirements. (LO 01)

A. A car with the mentioned specifications is parked on a banked road with an angle $\emptyset = 4\ deg$. — 25%



a. Derive equations to determine the forces acting on each wheel. — 15%

b. Calculate the forces acting on each wheel considering, — 10%

m	$980\ kg$
h	$0.6m$
l	$1.52m$
b_1	b_2

B. Go through the following bicycle model vehicle data. — 25%

Wheelbase	$2.65\ m$
Total Weight	$16.5\ kN$
Front & Rear Weight Distribution	$57 : 43$
Front Cornering Stiffness	$-2.85\ kN/deg$
Rear Cornering Stiffness	$-2.6\ kN/deg$
CG height of the Vehicle from the Ground	$0.508\ m$

The above-mentioned vehicle is travelling on a straight flat road. A steady crosswind applies a 444.8N force, 0.46m in front of the CG. Calculate the Steady State Steer Angle needed to counteract the crosswind such that the car travels in a straight line.

	C.	Suppose a two degree of freedom vehicle has the following characteristic equation in Yaw. $$s^2 + 1.4s + 13 = 0$$		20%
		a.	Calculate the underdamped natural frequency, damped natural frequency and damping ratio of the vehicle.	10%
		b.	Is the vehicle stable or unstable?	5%
		c.	Is the vehicle underdamped, overdamped or critically damped?	5%
	D.	Consider a Street Corvette P275/40ZR17 tire which produces a lateral force of -2.58kN according RCVD as per the given working condition.		30%
		a.	Calculate the total drag of four-wheels of a vehicle with mass 1360kg if all tires are operating at a slip angle of $3\,deg$ and have a rolling resistance coefficient of 0.022.	25%
		b.	Calculate the power required to drive the vehicle at $13.4\,m/s$ ignoring aerodynamic forces. For simplicity assume all tyres have equal normal loads.	5%

(02.) Calculate internal forces in an IC engine and model a simple IC engine. (LO 02)

A. A model Porshe 911 turbo has a flat 6-cylinder twin turbo engine with 3,596 cm^3 total displacement. The engine provides a maximum power (P_M) of $353kW$ at $6{,}000\ r.p.m.\ (\omega_M)$ and a maximum torque (T_M) of $620Nm$ at $5{,}000\ r.p.m.\ (\omega_e)$. The car weighs around $1{,}585kg$ and can move from $0\ km/h$ to $96\ km/h$ in $3.5\ sec$. The Porshe 911 turbo has a maximum speed of $310\ km/h$. — 30%

a. Determine the power performance and torque performance of the Porshe 911 turbo. — 20%

b. Determine the power to mass ratio. — 10%

B. A six-cylinder engine has a displacement of $2.30L$ a compression ratio of 8 and a brake power of $42.5kW$ at $2{,}400\ rev/min$, a mechanical efficiency of 75%, a card factor of 0.85, a suction pressure of $100kPa$, and a polytropic exponent of 1.30. — 50%

a. Calculate the Break Mean Effective Pressure of the whole engine — 10%

b. Calculate the Indicated Mean Effective Pressure. — 10%

c. Determine the P_4 using the Ideal Indicator Diagram for the Four Stroke Engine considering $k = 1.3$ and considering $P_1 = 100kPa$. — 10%

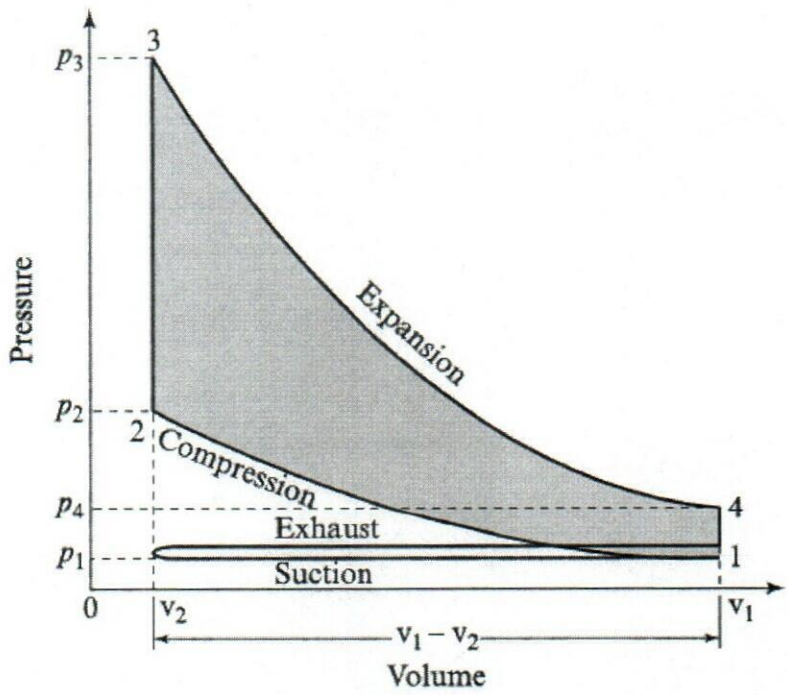
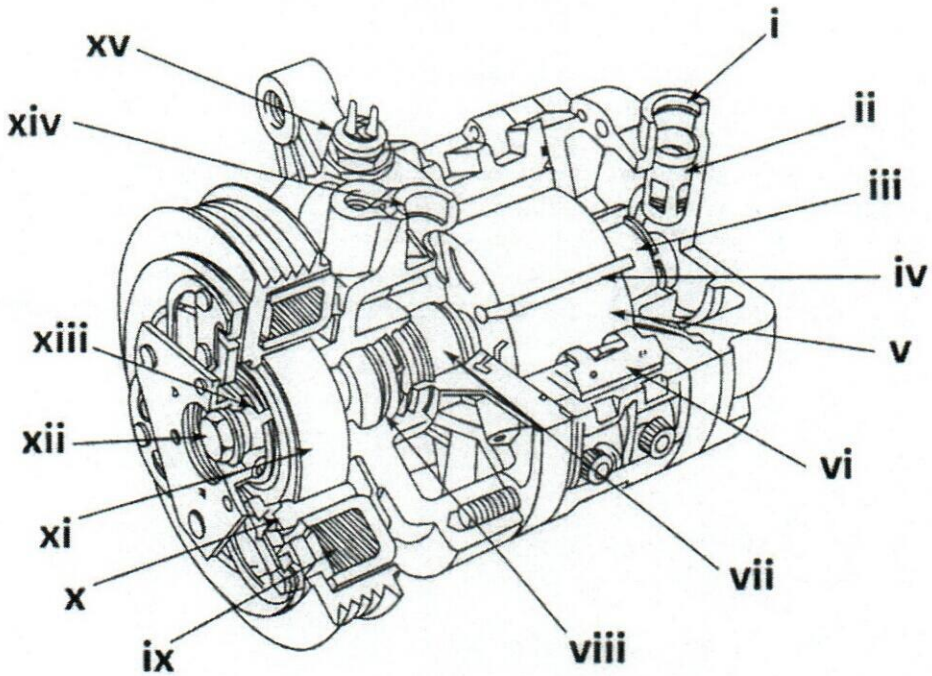


Figure 1 – An Ideal Indicator Diagram for a Four Stroke Engine

d. Calculate the Percentage Clearance. — 20%

C. State the Two Conditions which is being ensured when arranging the Cranks or Counterweights of the crank gear and how the stated conditions are being checked. — 20%

(03.)	Design a Heating and ventilation system for an automobile. (LO 03)				
	A.	a.	State the basic function of an Automotive Air Conditioner System.	10%	30%
		b.	State the Four Stages in the Refrigeration Cycle of an air-conditioning system.	5%	
		c.	Explain the main function and the working principle of the Air Compressor Clutch	15%	
	B.	Explain the operational criteria of an Automobile Air Conditioning System.			20%
	C.	Identify the components depicted by the Figure 02.  *Figure 02*			30%
	D.	List five properties of Refrigerants.			20%

(04.) Determine aerodynamic performance of vehicles using wind tunnel experiments and CFD software. (LO 04)

Table 1 - Standard Atmospheric Conditions

Standard Temperature	$15\,°C$
Standard Pressure	$101.325kPa$
Air Specific Weight	$1.225\,kg/m^3$
Standard Gravity	$9.8\,m/s^2$
Kinematic Viscosity	$1.48\times10^{-5}\,m^2/s$
Absolute Coefficient of Viscosity	$1.81\times10^{-5}\,kg/ms$

A. Assume air at standard temperature and pressure is moving past an object with a characteristic length of $6m$ at $26.8\ m/s$. — 20%

a. Calculate the Reynolds Number for the above-mentioned condition. — 10%

b. What air speed is required to test a $1/4$ scale model and have similar flow to full scale object. — 10%

B. Assume a flat level roadway with a tire road friction coefficient of 0.75. Suppose a particular race car generates a downforce of $2.224kN$ at $44.7\,m/s$. — 50%

a. Calculate the increase in speed which this vehicle can achieve on a $30.48m$ radius skid-pad when compared to the speed achieved without aerodynamics. — 30%

Calculate the lift vs velocity ratio using the above data assuming,

$$-Downforce = lift = kV^2$$

Prove that $V = \sqrt{\dfrac{\mu W}{\left(W/_{gR}\right)+\mu k}}$

b. Repeat for a skid-pad of radius $152.4m$. — 10%

c. Is there a dramatic improvement at this speed and explain? — 10%

C. List five components of Drag. — 10%

D. Write a short description on vortexes including, what is a vortex, how they are being generated, advantages, the devices used to create vortexes, — 20%

DATA SHEET

$F_{yF} = C_{\alpha F} * \alpha_F$
$F_{yR} = C_{\alpha R} * \alpha_R$
$\delta = \beta - \alpha_F$
$s^2 + 2\zeta\omega_n s + {\omega_n}^2 = 0$
$T \text{ or } D = F_x \cos\alpha + F_y \sin\alpha$
$P = FV$
$P_e = \sum_{i=1}^{3} P_i * {W_e}^i$
$P_e = (P_1\omega_e) + (P_2{\omega_e}^2) + (P_3{\omega_e}^3)$
$P_1 = \frac{P_M}{\omega_M}$
$P_2 = \frac{P_M}{{\omega_M}^2}$
$P_3 = \frac{P_M}{{\omega_M}^3}$
$T_e = \frac{P_e}{\omega_e}$
$B_p = \frac{\text{BMEP} * \text{LAnK}}{60{,}000}$
$P_i = \frac{P_b}{e_m}$
$P_4 = \left[(k-1)\frac{R-1}{R^k - R} * \frac{P_i}{f_c}\right] + P_1$
$V_1 - V_2 = V_1 - \frac{V_1}{R} = \frac{V_1(R-1)}{R}$
$V_1 - V_2 = Volume\ Swept\ by\ the\ Piston$
$Re = \frac{\rho VL}{\mu} = \frac{VL}{v}$
$F_y = \mu F_z$
$F_z = W - Lift$
$a_y = \frac{V^2}{R}$

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Semester 07 First Sit Final Examination 2024

Module Code	:	**FE4312**
Module Title	:	**Engineer as an Entrepreneur**
Date	:	**26.11.2024**
Examiners	:	**Dr Kalpana Ambepitiya**
Time Allowed	:	**03 hours**

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- This paper consists of four (04) questions. You Should Answer **ALL** questions.
- Write clearly and legibly with a blue or black pen.
- Use only the **CINEC Answering Booklet**. Additional sheets may be requested from the invigilators.
- This paper contains 03 pages.

MATERIALS REQUIRED

- CINEC answering Booklet; Extra answering paper
- You may use a scientific calculator. This must not be programmable. This may be examined during the examination.

Question No. 01

Elon Musk

Elon Musk showed an early aptitude for technology and entrepreneurship. At 12, he created and sold a video game called Blastar. Despite facing challenges during his upbringing in South Africa, Musk's curiosity and determination shaped his career. After studying physics and economics at the University of Pennsylvania, he briefly pursued a PhD at Stanford but left to capitalize on the booming tech scene.

In 1995, Musk co-founded Zip2, which provided newspaper business directories and maps. This venture was a success, and it was eventually sold to Compaq for nearly $300 million. Musk then co-founded X.com, an online payment platform, which later became PayPal. Under his guidance, PayPal revolutionized online payments before being sold to eBay for $1.5 billion in 2002.

In 2002, he founded SpaceX intending to make space travel more affordable and ultimately enabling human colonization of Mars. SpaceX achieved significant milestones despite early failures, including launching and landing reusable rockets. The company's success has transformed the space industry and secured contracts with NASA and private companies.

In 2004, Musk invested in Tesla Motors and became its CEO and product architect. Tesla faced initial scepticism but grew to lead the electric vehicle (EV) market. Musk's vision of sustainable energy extended to ventures like SolarCity and the development of energy storage solutions like the Powerwall. Tesla's innovations disrupted the automotive and energy sectors, making EVs mainstream.

Musk also founded The Boring Company to address urban congestion by developing underground transportation systems. Another venture, Neuralink, focuses on brain-computer interface technology to enhance human capabilities and address neurological disorders.

Musk has contributed to various philanthropic initiatives, including funding for renewable energy projects, AI safety research through OpenAI, and disaster relief. Despite controversies, he has committed to using his wealth to address global challenges like climate change and education.

Elon Musk's ventures have redefined industries and inspired innovation worldwide. His ability to merge technology with ambitious goals demonstrates the transformative power of visionary leadership. Today, Musk continues to push the boundaries of what's possible, aiming to secure a sustainable and multi-planetary future for humanity.

Considering the facts given in the case study,

a) What are the five (05) characteristics of Elon Musk's early entrepreneurial journey? **(05 marks)**

b) What challenges did Elon Musk face while developing SpaceX? **(05 marks)**

c) How did Musk's involvement with Tesla Motors transform the electric vehicle market? **(05 marks)**

d) What is the purpose of Neuralink and The Boring Company in Elon Musk's vision for the future? **(05 marks)**

e) Discuss the impact of Elon Musk's ventures on global industries and innovation. Provide examples from his companies to support your answer. **(10 marks)**

f) Evaluate how Elon Musk's approach to philanthropy aligns with emerging business trends and competitive strategies in the technology sector. **(10 marks)**

(Total: 40 Marks)

Question No. 02

a) What is a business idea, provide an example. **(05 Marks)**

b) Briefly explain the link between Product/service feasibility and financial feasibility. **(05 Marks)**

c) Discuss the importance of the Competitive Analysis Grid. Provide your answer based on 02 examples. **(10 marks)**

(Total: 20 Marks)

Question No. 03

a) Briefly explain the difference between Business Angels and Venture Capital Firms. **(05 Marks)**

b) How do you define effective communication in teamwork? Provide an example. **(05 Marks)**

c) Managing finance is crucial for a start-up business. Do you agree with this statement? Explain how you would plan the finances for your start-up. **(10 marks)**

(Total: 20 Marks)

Question No. 04

a) Define Sustaining Innovation, Provide an example. **(05 Marks)**

b) List five (05) attributes of a Leader. **(05 Marks)**

c) Develop a Business Model Canvas for a startup offering an innovative food delivery service. Include key elements such as value proposition, customer segments, channels, revenue streams, cost structure, and key partnerships. Explain how each element contributes to the overall success of the business. **(10 Marks)**

(Total: 20 Marks)

----------End of the Paper ----------

Prepared by: Dr Kalpana Ambepitiya (20.11.2024)

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Faculty of Engineering & Technology
Department of Mechanical & Automotive Engineering
BSc Hons (Eng) Mechanical Engineering / Automotive Engineering / Mechatronics Engineering
Year 2 Semester 1 Final Examination 2024

Module Code	:	**ME2323**
Module Title	:	**Dynamics of Mechanical Systems**
Date/Time	:	**22nd July 2024 / 13.30-16.30**
Examiner	:	**Mr. Sriyarathna Peiris**
Time Allowed	:	**3 Hours**

INSTRUCTIONS TO CANDIDATES

- You should attempt **ALL** questions
- All questions carry equal marks
- Show all the working on the answer paper
- This paper contains 4 pages.

MATERIALS REQURIED

- Formulae sheet
- You may use a scientific calculator. This must not be programmable.

Student Number .....

Q1. If a plate shown in Fig. Q1 has a density of 8000 kg/m^3 and a thickness of 10 mm, determine its moment of inertia about an axis directed perpendicular to the page and passing through point O.

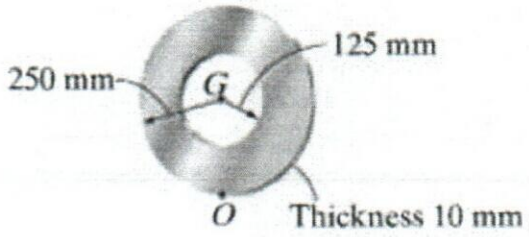


Fig. Q1

20 marks

Q2. A shaft of 100 mm diameter and 1 metre long is fixed at one end and other end carries a flywheel of mass 1 tonne.
Find the natural frequency of longitudinal and transverse vibrations taking Young's modulus for the shaft material as 200 GN/m^2.

20 marks

Q3. **(a)** For the geared system shown in Fig. Q3, the inertias in kg·m^2 are I_1= 0.2, for the motor shaft and I_2 = 0.5 for the load shaft. The motor speed ω_1 is six times faster than the load speed ω_2, so this device is called a *speed reducer*. Obtain the equation of motion

(a) in terms of ω_1 and

(b) in terms of ω_2, assuming that the motor torque T_1 and load torque T_2 are given.

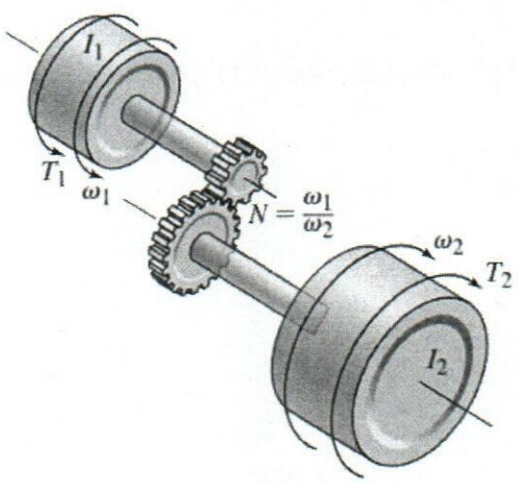


Fig. Q3

20 marks

Q4. The turning moment diagram for a multicylinder engine has been drawn to a scale 1 mm = 600 N-m vertically and 1 mm = 3° horizontally as shown in Fig. Q4. The intercepted areas between the output torque curve and the mean resistance line, taken in order from one end, are as follows:
+ 60, – 130, + 90, – 150, + 88, – 75 and + 117 mm^2, when the engine is running at a speed of 500 rpm. If the total fluctuation of speed is not to exceed ± 1.6% of the mean, find the necessary mass of the flywheel of radius 0.6 m.

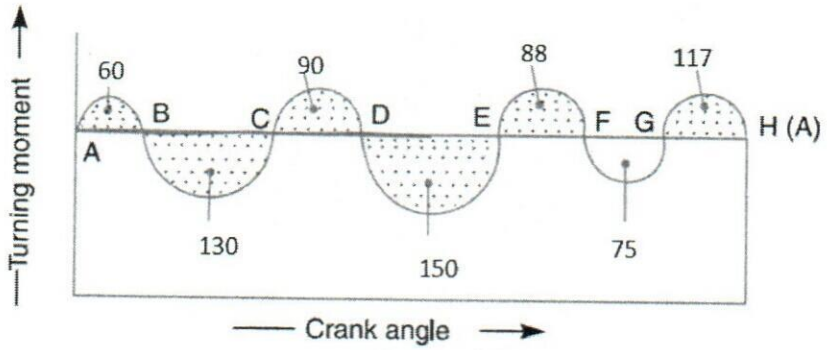


Fig. Q4

20 marks

Q5. **(a)** **(i)** Briefly discuss the importance of friction clutches in mechanical power transmission. **04 marks**

(ii) Name three types of friction clutches. **03 marks**

(iii) What are the material qualities essential for friction clutches? **03 marks**

(b) A single plate clutch transmits 8.5 kW at 1000 rpm. The coefficient of friction of the surface is 0.28. The maximum axial pressure is 0.08 N/mm^2.

(i) Determine the mean radius and face width of the friction lining if their ratio is 4. **06 marks**

(ii) Determine outer and inner radii of the clutch plate. **04 marks**

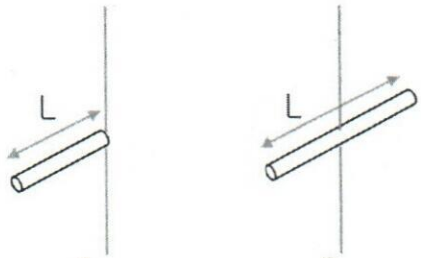
End of Questions

Formulae Sheet

1. Rate of change of angular momentum

$$T = \frac{d(I\omega)}{dt}$$

2. Moment of inertia of a bar



$I = \frac{1}{3}mL^2$ $I = \frac{1}{12}mL^2$

3. ΔE = Maximum K. E. – Minimum K. E

4. Maximum fluctuation of energy $= I\omega^2 C_s = mk^2\omega^2 C_s$

5. Axial trust by spring, $W = 2\pi C(r_1 - r_2)$

6. R = Mean radius of the friction surfaces $= \frac{2}{3}\left[\frac{(r_1)^3-(r_2)^3}{(r_1)^2-(r_2)^2}\right]$ for uniform pressure

7. $R = \frac{r_1+r_2}{2}$ for uniform wear

8. Frictional Torque $= \eta\mu$WR

9. $Pr = C$ (Constant)

10. Static deflection of a shaft *in longitudinal direction* $\delta = \frac{WL}{AE}$

11. Static deflection of a shaft *in transverese direction* $\delta = (WL^3)/3EI$

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Semester 3 First Sit Examination 2024

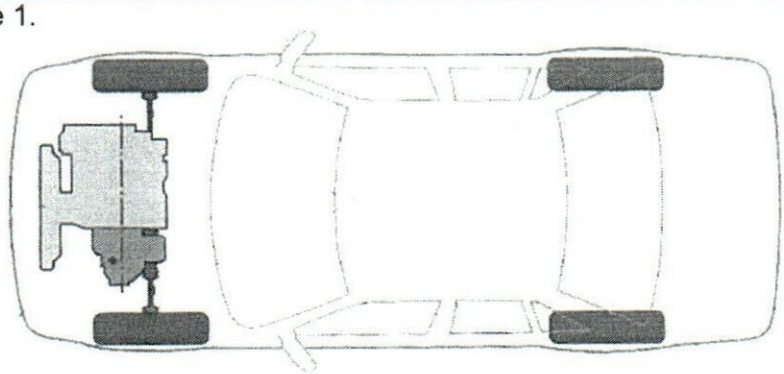
Module Code	:	**ME2316**
Module Title	:	**AUTOMOBILE TECHNOLOGY I**
Date	:	**16TH OF FEBRUARY 2024**
Examiners	:	**WASABHA Y SAMARATHUNGA**
Time Allowed	:	**03 hrs.**

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- This paper consists of **FOUR** questions. You Should Answer **ALL** the questions.
- Write clearly legibly with a blue or black pen.
- Use only the **CINEC Answering Booklet**. Additional sheets may be requested from the invigilators.
- This paper contains **8** pages.

MATERIALS REQURIED

- CINEC answering Booklet; Extra answering paper & Data sheets.
- You may use a scientific calculator. This must not be programmable. This may be examined during the examination.
- You may use additional data provided at the end of this examination paper (Data Sheet).

01.	Explain the history, layout and configuration of automobiles & explain the provisions of the Motor Traffic Act, and the current Emission Regulations			
	a.	Define the terms "Configuration" and "Layout" with respect to automobiles.	20%	100%
	b.	Study figure 1.  Figure 1		
		i. Identify the layout and the configuration of the depicted by figure 1.	10%	
		ii. Make a comment on advantages and the disadvantages of placing the power source of the automobile in the arrangement which is being depicted by figure 1.	20%	
	c.	Write a comparison between the 4WD systems and AWD systems.	30%	
		List down 5 main systems which can be found an Automobile.	20%	

02.	Describe the construction and operating principle of, systems, sub systems and main components of an automobile.			
	a.	Identify and name the components depicted by the numbers by referring the Figure 2 & 3.	30%	100%

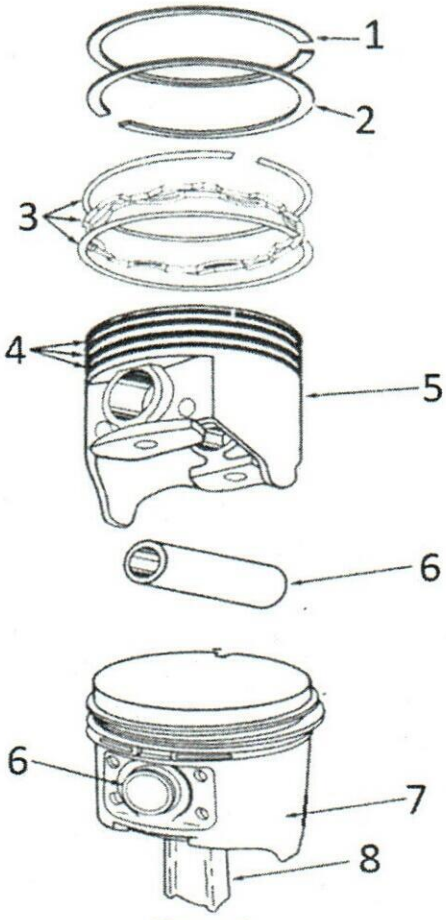


Figure 2

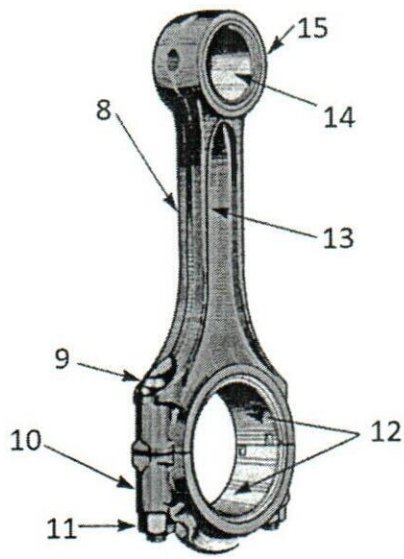
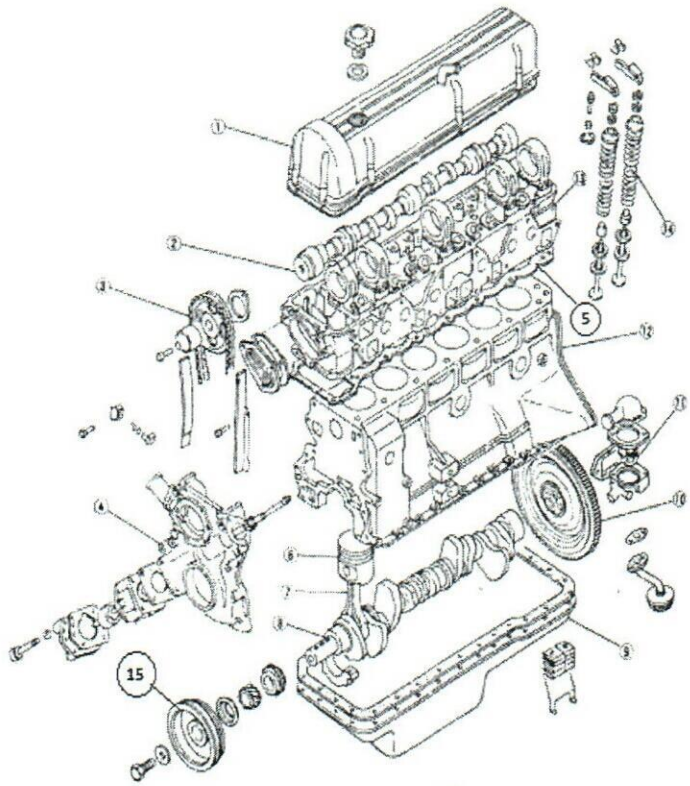
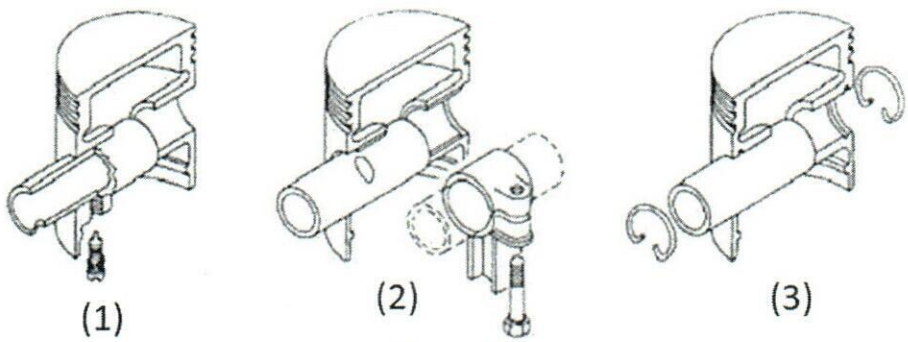
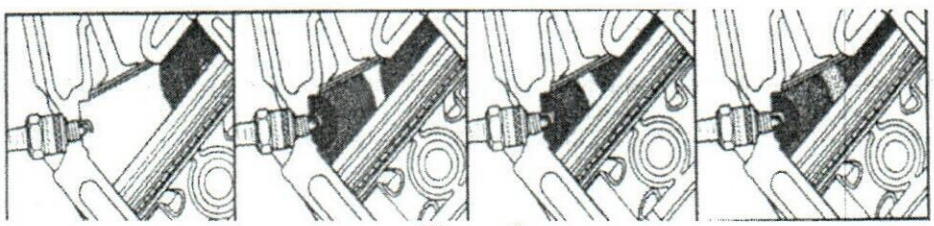
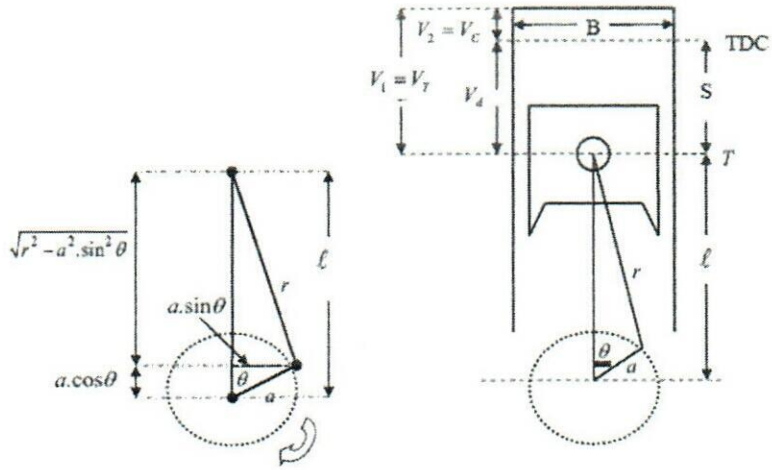


Figure 3

	b.	Identify and name the components depicted by the numbers by referring the Figure 4.  *Figure 4*	30%	
	c.	Identify and compare the types of pistons pins by referring the Figure 5.  *Figure 5*	20%	
	d.	State 5 operations which are being carried out on a sand casted block after removing the cores.	20%	

03.	Explain the different types of fuels used in SI and CI engines and the respective combustion processes				
	a.	Point out the four main sources of air pollutants from the automobiles and how the volume of pollutants released to the environment from each source is being controlled by the vehicle emission system.		20%	100%
	b.	A sample of gasoline fuel is said to have an Octane Rating of 95.			
		i.	Name the quality which is being governed by the Octane Rating of Gasoline.	5%	
		ii.	Name the two types of reference fuels and their qualities which are being used in determining the octane rating of a produced sample of gasoline.	10%	
		iii.	State the three test procedures which are being used in standard practice in determining the octane rating of a gasoline sample.	15%	
	c.	Identify the abnormal combustion condition which is depicted by figure 6 and write a short description of the occurrence (name, how it happens, why is happens, when it happens, issues it arises, causes) of the mentioned abnormal combustion.  *Figure 6*		20%	
	d.	Write short descriptions on the following, I. Stoichiometric Ratio II. Lean Combustion III. Rich Combustion			

04.	Perform calculations to determine engine performance parameters			
	a.	 *Figure 7* Show that the piston displacement for any given crank angle (θ) is given by, $l_{(\theta)} = a\cos\theta + \sqrt{r^2 - (a\sin\theta)^2}$	20%	100%
	b.	A 4G63t is a 1997cc inline four-cylinder turbocharged engine that operates on four stroke cycle @ 6,500 R.P.M. The compression ratio is 8.8:1, the length of a connecting rod is 156 mm, and the engine is square engine where B = S. Calculate the following considering S = 2a I. Cylinder Stroke Length II. Average Piston Speed III. The distance the piston has travelled @ $\theta = 45°$ (The distance between crank axis and the wrist pin axis)	25%	
	c.	An eight-cylinder four stroke automobile engine of 85.7mm bore and 82.5mm stroke with a compression ratio of 7 is tested at 4000 rounds per minute on a dynamometer which has a 0.5335m arm. During a 10-minute test at a dynamometer scale beam reading of 400N was read and a 4.55kg of gasoline with a heating value is 46,000kJ/kg were burnt. And air at 294K with 10×10^4 N/m^2 is supplied to the carburettor at the rate of 5.44kg per min. Determine the following, I. The brake power delivered. II. The brake means effective pressure. III. The brake specific fuel consumption. IV. The brake thermal efficiency.	25%	
	d.	The Following were recorded in the specification sheet of the RB26DETT 2.8L High Response 6 Cylinder four stroke gasoline engine by HKS.	30%	

Diameter	87.0mm
Stroke	77.7mm
Speed	9,000rpm
Displacement	2,771cc
HV	46,000 kJ/kg
Torque	784.532 Nm
Brake Power	581.7353 KW
Mechanical Efficiency	90%
Compression Ratio	8.6

		Calculate the following, I. Brake Power II. Indicated Power III. Indicated Mean Effective Pressure IV. Frictional Loss V. Compression Volume		

DATA SHEET

Equivalence Ratio	$\phi = \frac{A/F_{st}}{A/F}$
Lambda value(λ)	$\lambda = \frac{1}{\phi}$
Pythagorean Identity	$1 = \sin^2\theta + cos^2\theta$
The Displacement Volume	$d_p = \left(\frac{\pi}{4}\right) d^2 L$
Engine Capacity	$V_D = \left(\frac{\pi}{4}\right) B^2 S \times K = d_p \times K$
Average Piston Speed	$\overline{U_p} = \frac{2S * N}{60}$
Distance between the Wrist Pin Axis and the Main Journal Axis at a given Crank Angle	$l_{(\theta)} = acos\theta + \sqrt{r^2 - (a\sin\theta)^2}$
Brake Power	$BP = \left(\frac{2\pi TN}{60 \times 1000}\right)$
Mechanical Efficiency	$\eta_m = \frac{BP}{IP}$
Indicated Power for a Four Stroke Engine	$IP = \frac{P_i * LANK}{2 * 60{,}000}$
Frictional Power	$FP = IP - BP$
Brake Specific Fuel Consumption	$(BSFC) = \frac{60.W_f}{\mathrm{BP}}$
Fuel Flow Rate	$W_f = \frac{Amount\ of\ Fuel\ Delivered}{Time\ Period}$
Brake Thermal Efficiency	$\eta_B = \frac{60.\mathrm{BP}}{W_f.HV}$
Compression Ratio	$r = r_c = \frac{V_t}{V_c} = \frac{V_c + d_p}{V_c}$
Brake Mean Effective Pressure	$bmep = \frac{Bp * 2 * 60{,}000}{LANK}$
Indicated Mean Effective Pressure	$P_i = \frac{IP * 2 * 60{,}000}{LANK}$

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Faculty of Engineering & Technology

Department of Mechanical & Automotive Engineering

BSc Hons (Eng) in Mechanical Engineering

Semester 8 Re-sit Examination 2024

Module Code	:	**ME4324**
Module Title	:	**PRODUCTION ENGINEERING, PLANNING & CONTROL**
Date	:	**11th September 2024 from 1:30p.m. to 4:30p.m.**
Examiners	:	**Mr. Vijitha Abeysundera**
Time Allowed	:	**03 hours**

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- This paper consists of **05 questions**. You Should Answer **ALL** questions.
- Write clearly legibly with a blue or black pen.
- Use only the **CINEC Answering Booklet**. Additional sheets may be requested from the invigilators.
- This paper contains 12 pages.

MATERIALS REQURIED

- CINEC answering Booklet.
- You may use a scientific calculator. This must not be programmable. This may be examined during the examination.
- You may use additional data provided at the end of this examination paper

Question 1

(i) Discuss the importance steps in New Product Development Process **(20 marks)**

(ii) Distinguish the terms Market Driven and Technology Driven Approaches in Production Planning. **(20 marks)**

(iii) The Production Engineer is having two options as given below in one particular function of his production line.

(a) Through Automation

Investment Cost Rs. 10,000

Monthly variable cost of operating the system Rs. 100 (inclusive of all expenses)

Maximum volume that can be produced through automation process is 8000 units per year.

(b) Through Manually

Initial training cost Rs. 700

Monthly variable cost of operating Rs.700 (including salary and all other benefits)

Maximum volume that can be produced through automation process is 6000 units per year.

Advice the production engineer about the suitability of the options available to him. **(60 marks)**

Question 2

(i) Discuss the differences between Level Strategy and Chase Strategy in Aggregate Planning. **(30 Marks)**

(ii) 10 workers assigned to the production line, each capable of producing approximately 15 boats per month and each month has the same number of production days. Hiring and training cost of $400 per worker and layoff cost is $1,000 per worker. The production cost (labor, material, and overhead) is $300 per boat. Boat produced in overtime adds $60 in labor cost, and each worker can only produce an extra three boats per month using overtime. If they keep any boats in inventory it will cost them $6 per boat per month for any boat in inventory at the end of the month. The stockout cost of the company $120 in profit and currently have no boats in inventory. Using this simple data prepare the production plan to meet the demand given below. **(70 Marks)**

Table -1

Month	Jan	Feb	Mar	Apr	May	June
Demand	250	600	420	560	610	580

Question 3

(i) Explain the importance of Forecasting with regard to Production, Inventory and Human Resources **(20 marks)**

(ii) Discuss the importance of Delphi Method in forecasting. **(20 Marks)**

(iii) Briefly explain two shortcomings in Delphi Method. **(20 marks)**

(iv) Discuss the importance of Life Cycle Analysis in forecasting. **(20 Marks)**

(v) Distinguish the terms Moving Average and Weighted Moving Average method in Time Series Method. **(20 marks)**

Question 4

(i) Discuss the factors with suitable examples that you have to consider when selecting a suitable location to commence your new business venture. **(40 marks)**

(ii) Gold Pvt Limited is considering a new plant location for either City R or City S in addition to two existing factories in City P and City Q. Plants in P and Q are catering to warehouses in city A, B, C and D. The unit cost of transportation, the availability of goods and the requirements are given below.

Table-2

City of Origin	Transportation Costs per Unit to warehouses (Rs.)				Units Available
	A	B	C	D	
P	4	3	5	7	100
Q	5	8	5	2	150
R	3	6	2	4	100
S	2	7	3	2	100
Units Required	75	50	125	100	

a. Find the suitable location between R and S using North West Corner Rule (Initial Solution). **(60 marks)**

Question 5

(i) Discuss three key areas that you have to give due consideration when you are managing a maintenance program. **(30 marks)**

(ii) Activities involving complete overhaul of a gear box is given below with required time and predecessor events.

Table-3

Task	Immediate predecessor	Duration (Days)
A	No	3
B	A	4
C	A	6
D	B	6
E	B	4
F	C	4
G	D	6
H	E,F	8

(i) Draw the network diagram **(30 marks)**

(ii) Find the critical path and the duration **(20 marks)**

(iii) What activities to be crashed in order to minimize the total duration. **(20 marks)**

- END -

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Faculty of Engineering & Technology
Department of Mechanical and Automotive Engineering
BSc Hons (Eng) Automotive Engineering / Mechanical Engineering / Mechatronics Engineering
Semester 4 First Sit Examination 2024

Module Code	:	**ME2325**
Module Title	:	**STRENGTH OF MATERIALS**
Date	:	**26th of July 2024**
Examiner	:	**Mr. Rashmika Wickrama**
Time Allowed	:	**3 Hours**

INSTRUCTIONS TO CANDIDATES

- This is a **closed-book** examination.
- This paper consists of **FIVE** questions. You Should Answer **ALL** the questions.
- Write clearly and legibly with a blue or black pen.
- Use only the **CINEC Answering Booklet**. Additional sheets may be requested from the invigilators.
- This paper contains 8 pages.

MATERIALS REQUIRED

- CINEC answering booklet, extra answering papers.
- You may use a scientific calculator. This must not be programmable. This may be examined during the examination.
- You may use additional data provided at the end of this examination paper (Data Sheet).

STUDENT NUMBER .....

Question 01

a) **Figure 1** shows a member that is subjected to two perpendicular direct stresses σ_1, σ_2, and a simple shear stress τ.

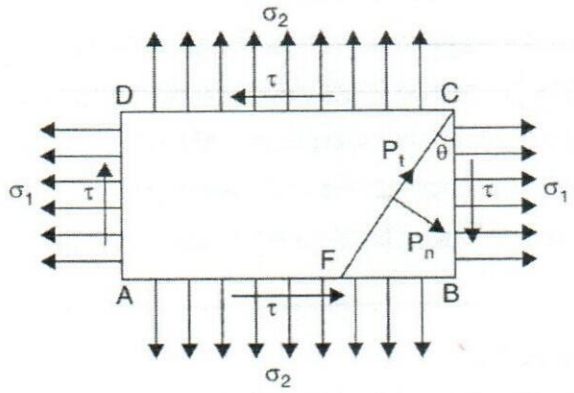


Figure 1

i. Derive the following formulas for the normal and tangential stresses of the FC plane. **40%**

$$\sigma_n = \frac{\sigma_1 + \sigma_2}{2} + \frac{\sigma_1 - \sigma_2}{2}\cos 2\theta + \tau \sin 2\theta$$

$$\sigma_t = \frac{\sigma_1 - \sigma_2}{2} \sin 2\theta - \tau \cos 2\theta$$

ii. Find the major and minor principal planes of the system. **20%**

40%

b) In a two-dimensional stress system, the direct stresses on two mutually perpendicular planes are 100 MN/m^2 and σ MN/m^2. These planes also carry a shear stress of 40 MN/m^2. If the factor of safety on the elastic limit is 2.5, then find the value of σ when shear strain energy is minimum.

Question 02

A cast iron beam of length 9 m is simply supported, carrying a uniformly distributed load of 10 kN/m length on the part of the span as shown in **Figure 2-a.** The cross-section of the beam is shown in **Figure 2-b**.

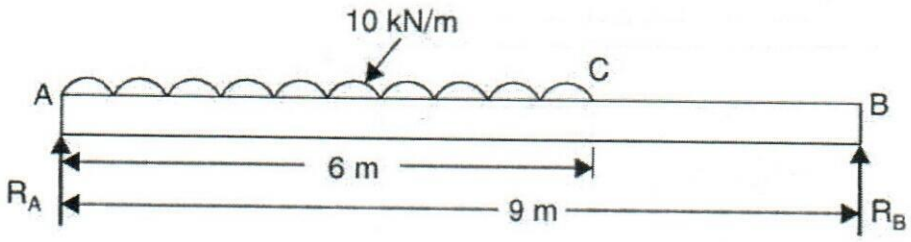


Figure 2-a

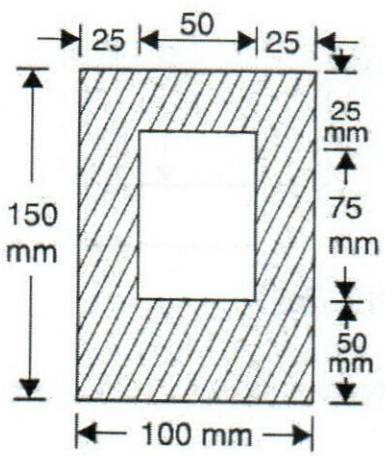


Figure2-b

i. Calculate the support reactions and draw the bending moment diagram of the beam neglecting the weight of the beam. **45%**

ii. Determine the maximum tensile and compressive stress induced in the beam. **55%**

Question 03

Figure 3 shows the I section of a beam with a depth of web d, the overall depth of section D, the thickness of web b, and the overall width of section B. The beam is subjected to a shear force F, at a section.

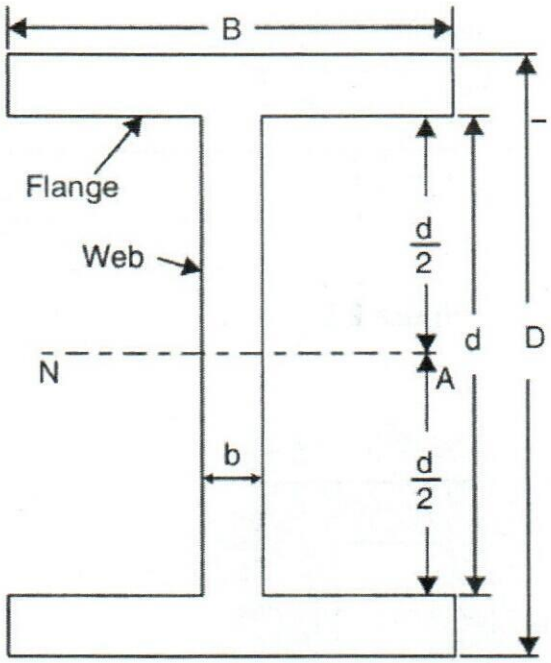


Figure 3

The shear stress at a distance y from the neutral axis is given by the following equation.

$$\tau = F\,\frac{A\,\bar{y}}{I\,b}$$

i. Develop the following equations to determine the shear stress distribution in the flange (τ_F) and the web (τ_W). **60%**

$$\tau_F = \frac{F}{2I}\left(\frac{D^2}{2} - y^2\right)$$

$$\tau_W = \frac{F}{Ib}\left[\frac{B}{8}(D^2 - d^2) + \frac{b}{2}\left(\frac{d^2}{4} - y^2\right)\right]$$

ii. Draw the shear force distribution diagram for the I section clearly showing the maximum shear stress and its location. **40%**

Question 04

a) A boiler is subjected to an internal steam pressure of 3 N/mm^2. The thickness of the boilerplate is 2.5 cm, the factor of safety is 3 and the ultimate tensile strength is 375 N/mm^2. Determine the maximum diameter, when the efficiency of the longitudinal joint is 90% and that of the circumferential joint is 35%. **50%**

b) A spherical vessel 1.5 m in diameter is subjected to an internal pressure of 2 N/mm^2. Determine the thickness of the plate required if maximum stress is not to exceed 150 N/mm^2 and joint efficiency is 75%. Determine the increase in volume of the vessel. Poisson's ratio is 0.5. **50%**

Question 05

a) An end-capped thick-walled cylinder with an internal radius of a and external radius of b is subjected to the internal pressure of P_i and external pressure of P_e. Determine the hoop stress σ_h, and radial stress σ_r, as a function of radial coordinate r using Lame's theorem. **50%**

$$\sigma_r = A - \frac{B}{r^2}$$

$$\sigma_h = A + \frac{B}{r^2}$$

Determine the axial stress σ_a for the above cylinder. **10%**

a) Determine the maximum and minimum hoop stress across the section of a pipe of 400 mm internal diameter and 100 mm thick, when the pipe contains a fluid at a pressure of 8 N/mm^2. Also, sketch the radial pressure distribution and hoop stress distribution across the section. Determine the required minimum yield strength of the material using the maximum principal stress theory if the safety factor is 3. **40%**

Formula Sheet

Stress transformation

$$\sigma_n = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta$$
$$\tau = \frac{\sigma_x - \sigma_y}{2}\sin 2\theta - \tau_{xy}\cos 2\theta$$

Strain transformation

$$\varepsilon_n = \frac{\varepsilon_x + \varepsilon_y}{2} + \frac{\varepsilon_x - \varepsilon_y}{2}\cos 2\theta + \frac{\gamma_{xy}}{2}\sin 2\theta$$
$$\frac{\gamma}{2} = \frac{\varepsilon_x - \varepsilon_y}{2}\sin 2\theta - \frac{\gamma_{xy}}{2}\cos 2\theta$$

Principal stress and orientation

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + {\tau_{xy}}^2}$$
$$\theta_n = \frac{1}{2}\tan^{-1}\left(\frac{2\tau_{xy}}{\sigma_x - \sigma_y}\right)$$

Principal strain and orientation

$$\varepsilon_{1,2} = \frac{\varepsilon_x + \varepsilon_y}{2} \pm \sqrt{\left(\frac{\varepsilon_x - \varepsilon_y}{2}\right)^2 + \left(\frac{\gamma_{xy}}{2}\right)^2}$$
$$\theta_n = \frac{1}{2}\tan^{-1}\left(\frac{\gamma_{xy}}{\varepsilon_x - \varepsilon_y}\right)$$

Constitutive equations

$$\varepsilon_x = \frac{1}{E}\left(\sigma_x - \nu(\sigma_y + \sigma_z)\right)$$
$$\varepsilon_y = \frac{1}{E}\left(\sigma_y - \nu(\sigma_x + \sigma_z)\right)$$
$$\varepsilon_z = \frac{1}{E}\left(\sigma_z - \nu(\sigma_x + \sigma_y)\right)$$
$$\sigma_x = \frac{E}{(1+\upsilon)(1-2\upsilon)}\left[(1-\upsilon)\varepsilon_x + \upsilon(\varepsilon_y + \varepsilon_z)\right]$$
$$\sigma_y = \frac{E}{(1+\upsilon)(1-2\upsilon)}\left[(1-\upsilon)\varepsilon_y + \upsilon(\varepsilon_x + \varepsilon_z)\right]$$
$$\sigma_z = \frac{E}{(1+\upsilon)(1-2\upsilon)}\left[(1-\upsilon)\varepsilon_z + \upsilon(\varepsilon_x + \varepsilon_y)\right]$$

Relationship between elastic constants

$$G = \frac{E}{2(1+\nu)}$$
$$K = \frac{E}{3(1-2\nu)}$$

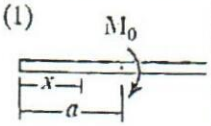
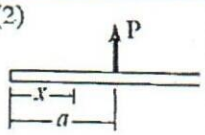
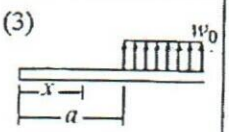
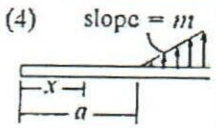
Flexure formula and shear formula for beams

$$\sigma = -\frac{My}{I}$$
$$\tau = V\frac{A'\bar{y}'}{It}$$

Bending moment function for beams

$$M(x) = EI\frac{d^2v}{dx^2}$$

Discontinuity functions for beams

Loading	Loading Function $w = w(x)$	Shear $V = \int w(x)dx$	Moment $M = \int Vdx$
(1) 	$w = M_0\langle x-a\rangle^{-2}$	$V = M_0\langle x-a\rangle^{-1}$	$M = M_0\langle x-a\rangle^{0}$
(2) 	$w = P\langle x-a\rangle^{-1}$	$V = P\langle x-a\rangle^{0}$	$M = P\langle x-a\rangle^{1}$
(3) 	$w = w_0\langle x-a\rangle^{0}$	$V = w_0\langle x-a\rangle^{1}$	$M = \frac{w_0}{2}\langle x-a\rangle^{2}$
(4) 	$w = m\langle x-a\rangle^{1}$	$V = \frac{m}{2}\langle x-a\rangle^{2}$	$M = \frac{m}{6}\langle x-a\rangle^{3}$

Torsion equation

$$\frac{T}{J} = \frac{\phi G}{L} = \frac{\tau}{\rho}$$

Euler's buckling equation

$$P_{cr} = \frac{\pi^2 EI}{(L_e)^2}$$

Lamé's equations

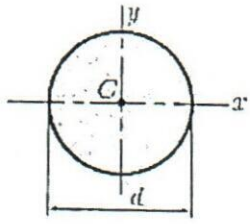
$$\sigma_r = A - \frac{B}{r^2}$$
$$\sigma_h = A + \frac{B}{r^2}$$

von Mises equivalent stress

$$\sigma_e = \frac{1}{\sqrt{2}}[(\sigma_1-\sigma_2)^2 + (\sigma_1-\sigma_3)^2 + (\sigma_2-\sigma_3)^2]^{\frac{1}{2}}$$

Geometric properties of a circular area

$$I_{xx} = I_{yy} = \frac{\pi d^4}{64}$$
$$J_C = \frac{\pi d^4}{32}$$

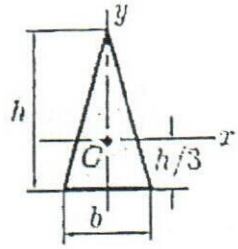


Geometric properties of a triangular area

$$I_{xx} = \frac{bh^3}{36}$$

$$I_{yy} = \frac{b^3h}{36}$$

$$J_c = \frac{bh}{36}(b^2 + h^2)$$



Stresses induced in thin cylinders

Hoop stress $\sigma_1 = \frac{p\,d}{2\,t\,\eta_l}$

Longitudinal stress $\sigma_2 = \frac{p\,d}{4\,t\eta_c}$

Stress-induced in thin spherical cells

$$\sigma_1 = \frac{p\,d}{4\,t}$$

Volumetric Strain in thin spherical cells

$$Volumetric\ Strain = \frac{3pd}{4Et}\,[1 - \nu]$$

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Semester 4 First Sit Examination 2024

Module Code	:	**ME2324**
Module Title	:	**AUTOMOBILE TECHNOLOGY II**
Date	:	**31ST OF JULY 2024**
Examiners	:	**WASABHA Y SAMARATHUNGA**
Time Allowed	:	**03 hrs.**

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- This paper consists of **FOUR** questions. You Should Answer **ALL** the questions.
- Write clearly legibly with a blue or black pen.
- Use only the **CINEC Answering Booklet**. Additional sheets may be requested from the invigilators.
- This paper contains **9** pages.

MATERIALS REQURIED

- CINEC answering Booklet; Extra answering paper & Data sheets.
- You may use a scientific calculator. This must not be programmable. This may be examined during the examination.
- You may use additional data provided at the end of this examination paper (Data Sheet).

(01)	Describe the construction and operating principle of transmission systems in automobiles				
	I.	a.	Note down the three main functions of the Clutch.	9%	25%
		b.	Identify the components depicted by the Figure 1 & Figure 2.	16%	

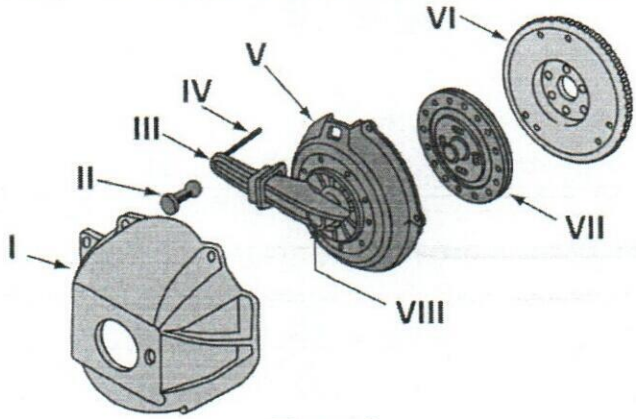


Figure 1

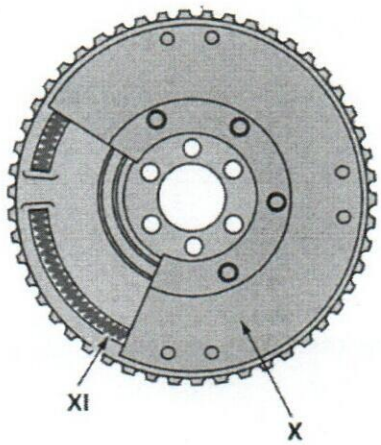


Figure 2

II.	a.	Justify the necessity on a Transmission or and Transaxle to be present in a vehicle.	6%	30%
	b.	Identify the components depicted by the Figure 3.	24%	

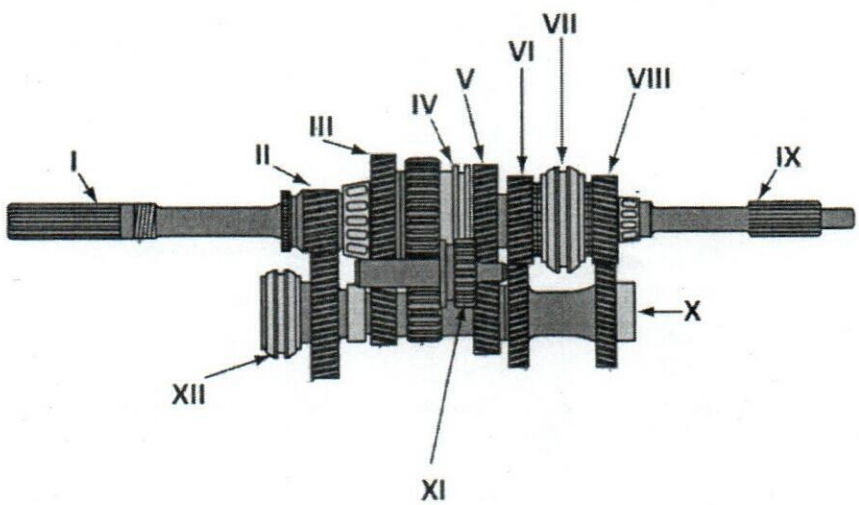
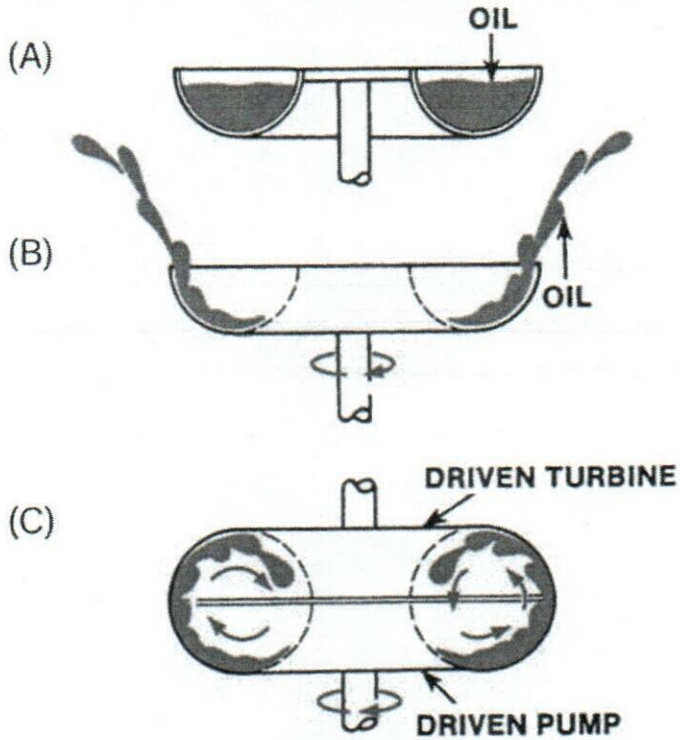
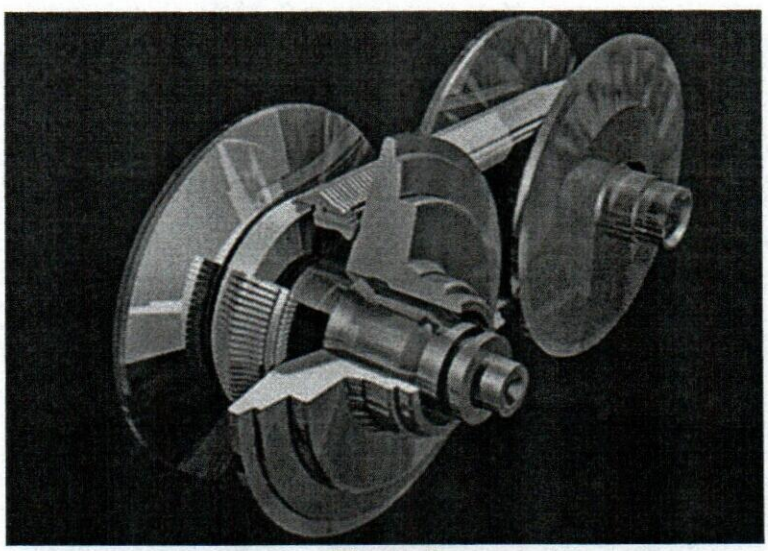


Figure 3

	III.	Discuss the working principle of the torque converter by referring the Figure 4.			20%
			 *Figure 4*		
	IV.	a.	List out the main components which can be found in a Simple Planetary Gear Set.	5%	25%
		b.	List down the two types of Planetary Gear Control Systems available in Automatic Transmission Boxes.	5%	
		c.	Mention key capability the automatic transmission clutches possess or transmission Bands.	5%	
		d.	Explain the working principle of the Transmission box depicted by the Figure 5.  *Figure 5*	10%	

(02)	Describe the construction and operating principle of suspension systems in automobiles				
	I.	a.	Note down five functions of the Suspension System.	10%	25%
		b.	Identify and explain the phenomenas depicted by the Figure 6 and Figure 7.	15%	

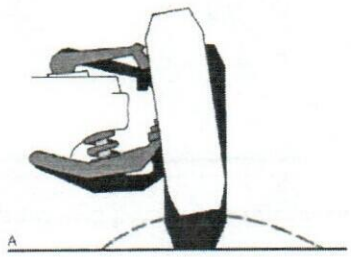


Figure 6

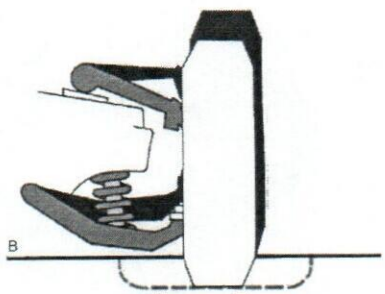


Figure 7

	II.	a.	Identify the components depicted by the Figure 8.	20%	25%

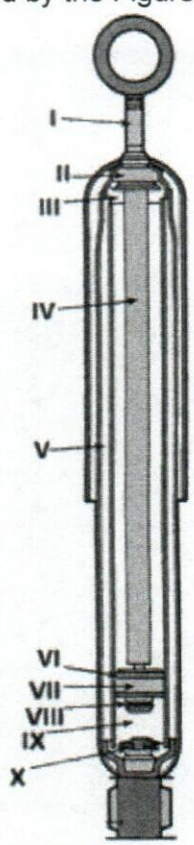


Figure 8

		b.	Name the two main types of shock absorbers available in the industry.	5%	

III. Go through the Figure 09. 25%

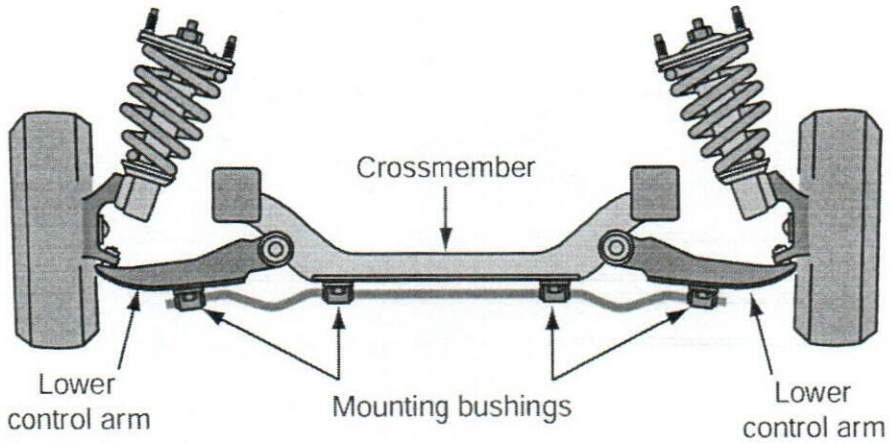


Figure 9

a.	Identify the component which is mounted to the crossmember and the lower control arms by using mounting bushings.	5%
b.	Mention the main role of the component which is mounted to the crossmember and the lower control arms by using mounting bushings.	10%
c.	Describe how the component which is mounted to the crossmember and the lower control arms by using mounting bushings acts if both the wheels go into a jounce & if only one wheel goes into a jounce.	10%

IV. Go through the Figure 10. 25%

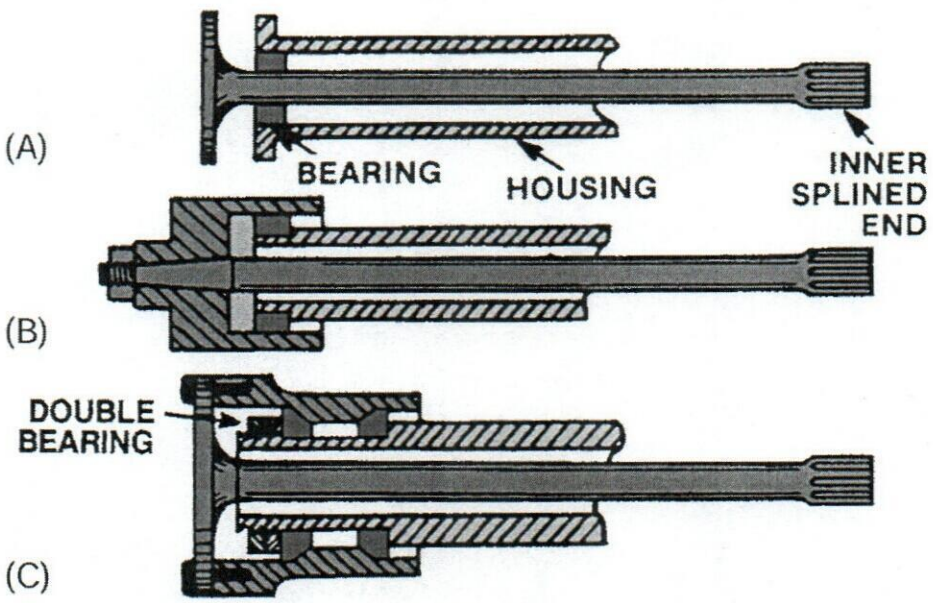
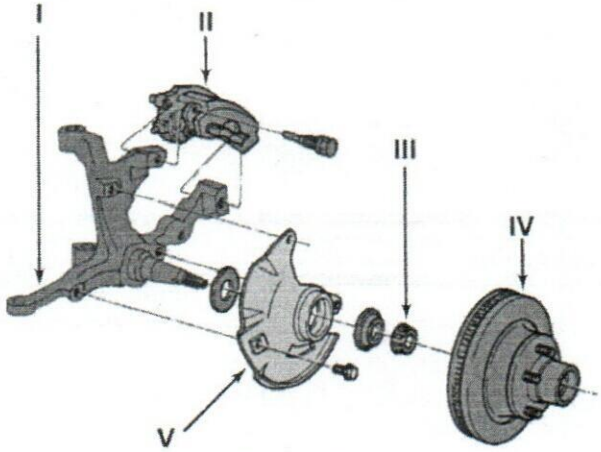
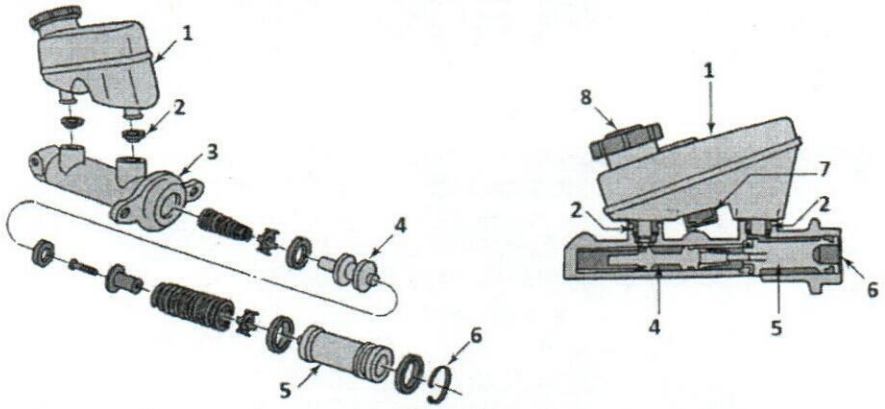
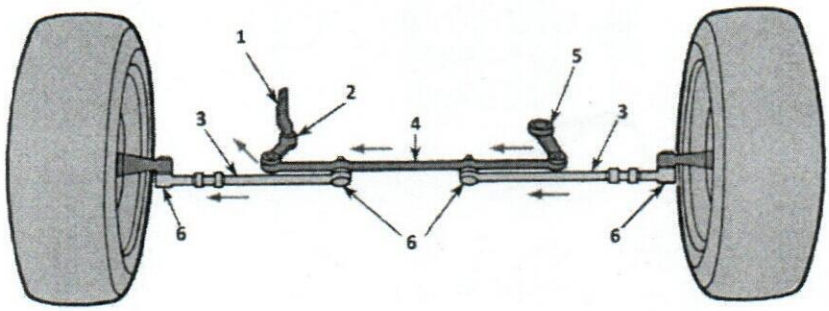
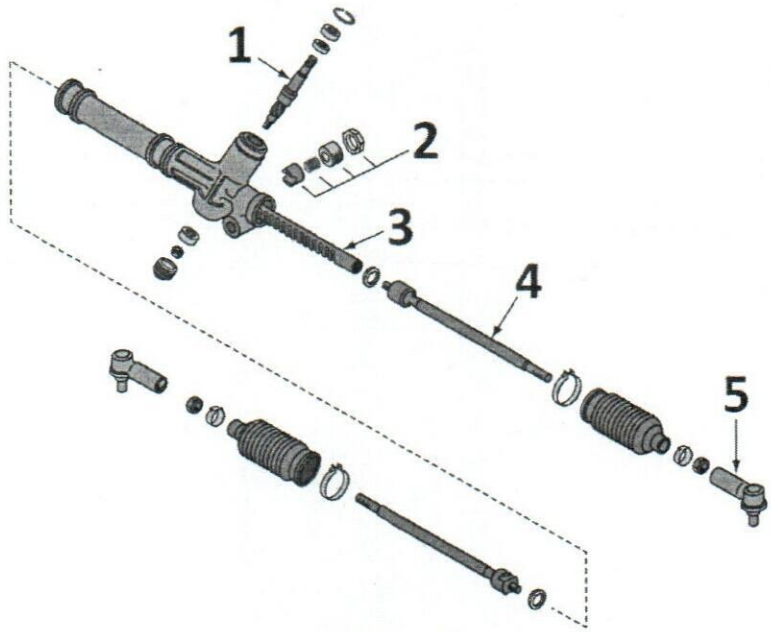
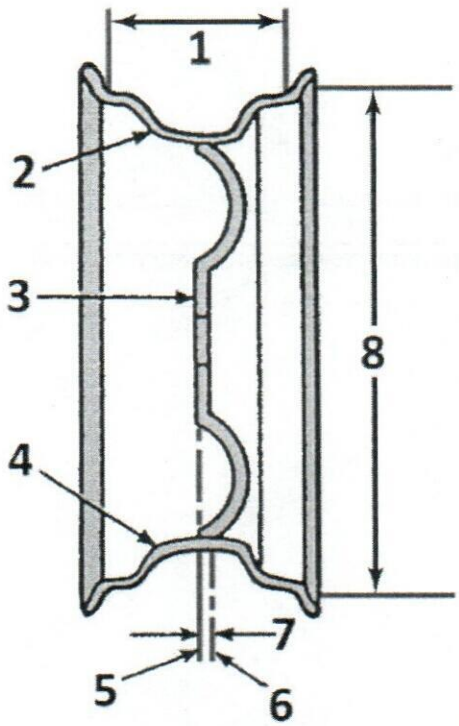
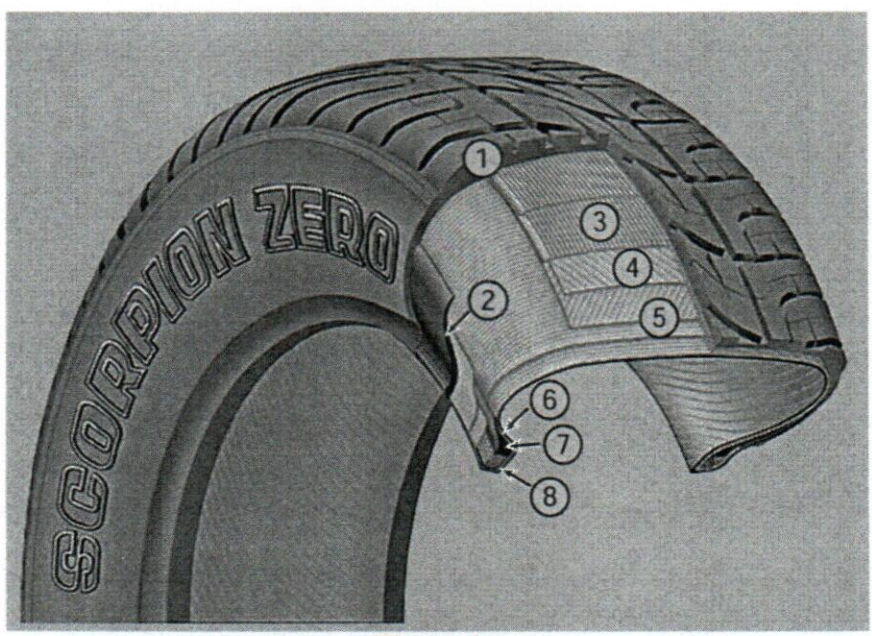


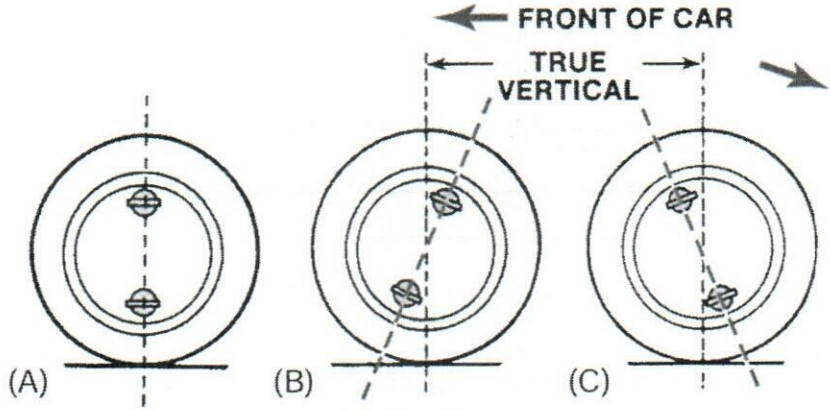
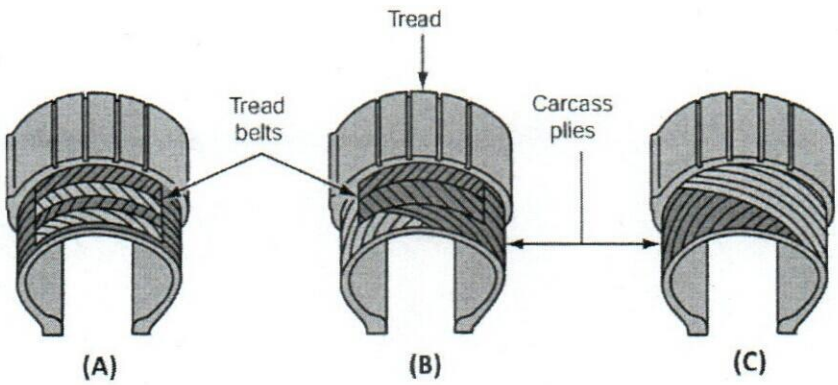
Figure 10

a.	Name the types of Axles depicted by the Figure 10.	10%
b.	Differentiate of Axles depicted by the Figure 10.	15%

(03)	Describe the construction and operating principle of braking and steering systems in automobiles				
	I.	a.	Identify the components depicted by the Figure 11.	10%	25%
			 *Figure 11*		
		b.	Explain the theory behind braking considering both the moving and stationery situations of an automobile using the conservation of energy.	15%	
	II.	a.	Note down the four factors affecting braking.	5%	25%
		b.	Note down the two types of Splits available in Braking Systems.	4%	
		c.	Identify the components depicted by the Figure 12.	16%	
			 *Figure 12*		
	III.	a.	Note down the purpose of the steering system.	5%	25%
		b.	Identify the components depicted by the Figure 13	12%	
			 *Figure 13*		
		c.	Define the term Steering Linkage.	5%	
		d.	Note down the main purpose of the Steering Linkage.	3%	

	IV.	a.	Describe the working principle of the steering rack.	10%	25%
		b.	Identify the components depicted by the Figure 14.	10%	
			 *Figure 14*		
		c.	Note down the two main types of Power Steering Systems	5%	

(04)	Describe the construction and operating principle of tyres for automobiles				
	I.	a.	Identify the components depicted by the Figure 15.	16%	25%
			 *Figure 15*		
		b.	Explain what is defined by Number 7 depicted in the Figure 15.	9%	
	II.	a.	Identify the components depicted by the Figure 16.	16%	25%
			 *Figure 16*		
		b.	Identify what is meant by each of the notations of the following piece of information printed on the tyre sidewall. P 205 / 75 R 15	9%	

	III.	a.	Define what is meant by wheel alignment and the principle followed when carrying out a wheel alignment service.	12.5%	25%
		b.	Identify and define the wheel alignment angle depicted by the Figure 17.  *Figure 17*	12.5%	
	IV.	a.	Identify and define the different types of tyre ply constructions depicted by the Figure 18.  *Figure 18*	21%	25%
		b.	List down the four types of tread patterns available.	4%	

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PAST PAPERS

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Not Applicable	Learning Resource Centre

Past Papers

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Faculty of Engineering & Technology
Department of Mechanical & Automotive Engineering
BSc Hons (Eng) Mechanical Engineering / Automotive Engineering / Mechatronics Engineering
Year 2 Semester 1 Final Examination 2024

Module Code	:	**ME2323**
Module Title	:	**Dynamics of Mechanical Systems**
Date/Time	:	**22nd July 2024 / 13.30-16.30**
Examiner	:	**Mr. Sriyarathna Peiris**
Time Allowed	:	**3 Hours**

INSTRUCTIONS TO CANDIDATES

- You should attempt **ALL** questions
- All questions carry equal marks
- Show all the working on the answer paper
- This paper contains 4 pages.

MATERIALS REQURIED

- Formulae sheet
- You may use a scientific calculator. This must not be programmable.

Student Number .....

Q1. If a plate shown in Fig. Q1 has a density of 8000 kg/m^3 and a thickness of 10 mm, determine its moment of inertia about an axis directed perpendicular to the page and passing through point O.

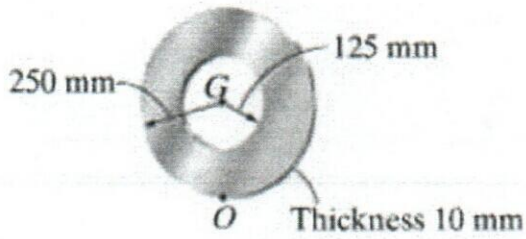


Fig. Q1

20 marks

Q2. A shaft of 100 mm diameter and 1 metre long is fixed at one end and other end carries a flywheel of mass 1 tonne.
Find the natural frequency of longitudinal and transverse vibrations taking Young's modulus for the shaft material as 200 GN/m^2.

20 marks

.

Q3. **(a)** For the geared system shown in Fig. Q3, the inertias in kg·m^2 are I_1= 0.2, for the motor shaft and I_2 = 0.5 for the load shaft. The motor speed ω_1 is six times faster than the load speed ω_2, so this device is called a *speed reducer*. Obtain the equation of motion

(a) in terms of ω_1 and

(b) in terms of ω_2, assuming that the motor torque T_1 and load torque T_2 are given.

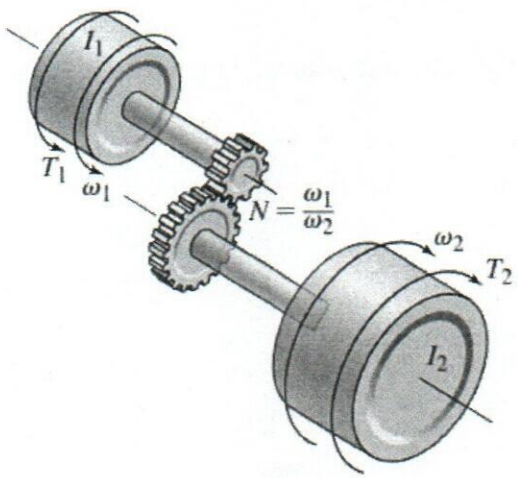


Fig. Q3

20 marks

Q4. The turning moment diagram for a multicylinder engine has been drawn to a scale 1 mm = 600 N-m vertically and 1 mm = 3° horizontally as shown in Fig. Q4. The intercepted areas between the output torque curve and the mean resistance line, taken in order from one end, are as follows:
+ 60, – 130, + 90, – 150, + 88, – 75 and + 117 mm^2, when the engine is running at a speed of 500 rpm. If the total fluctuation of speed is not to exceed ± 1.6% of the mean, find the necessary mass of the flywheel of radius 0.6 m.

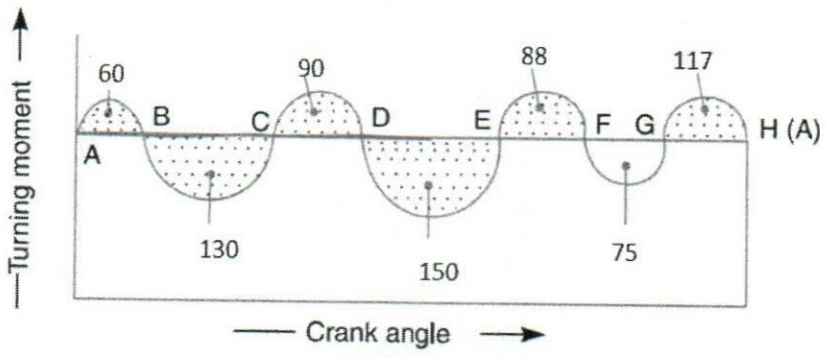


Fig. Q4

20 marks

Q5. **(a)** **(i)** Briefly discuss the importance of friction clutches in mechanical power transmission. **04 marks**

(ii) Name three types of friction clutches. **03 marks**

(iii) What are the material qualities essential for friction clutches? **03 marks**

(b) A single plate clutch transmits 8.5 kW at 1000 rpm. The coefficient of friction of the surface is 0.28. The maximum axial pressure is 0.08 N/mm^2.

(i) Determine the mean radius and face width of the friction lining if their ratio is 4. **06 marks**

(ii) Determine outer and inner radii of the clutch plate. **04 marks**

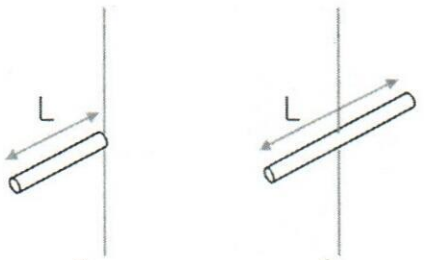
End of Questions

Formulae Sheet

1. Rate of change of angular momentum

$$T = \frac{d(I\omega)}{dt}$$

2. Moment of inertia of a bar



$$I = \frac{1}{3}mL^2 \qquad I = \frac{1}{12}mL^2$$

3. ΔE = Maximum K. E. – Minimum K. E

4. Maximum fluctuation of energy $= I\omega^2 C_s = mk^2\omega^2 C_s$

5. Axial trust by spring, $W = 2\pi C(r_1 - r_2)$

6. R = Mean radius of the friction surfaces $= \frac{2}{3}\left[\frac{(r_1)^3-(r_2)^3}{(r_1)^2-(r_2)^2}\right]$ for uniform pressure

7. $R = \frac{r_1+r_2}{2}$ for uniform wear

8. Frictional Torque $= \eta\mu$WR

9. $Pr = C$ (Constant)

10. Static deflection of a shaft *in longitudinal direction* $\delta = \frac{WL}{AE}$

11. Static deflection of a shaft *in transverese direction* $\delta = (WL^3)/3EI$

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Semester 3 First Sit Examination 2024

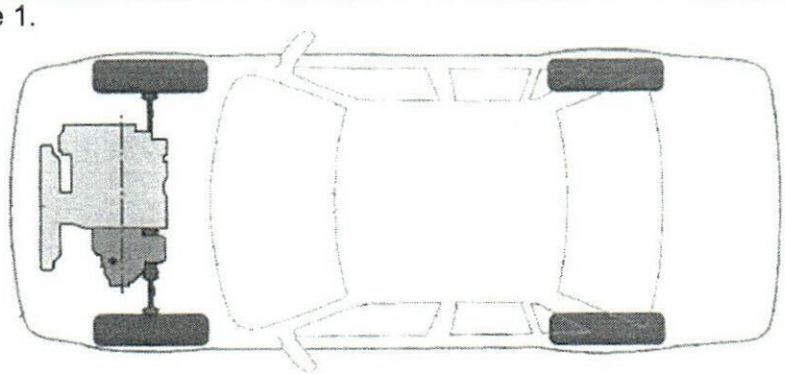
Module Code	:	**ME2316**
Module Title	:	**AUTOMOBILE TECHNOLOGY I**
Date	:	**16TH OF FEBRUARY 2024**
Examiners	:	**WASABHA Y SAMARATHUNGA**
Time Allowed	:	**03 hrs.**

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- This paper consists of **FOUR** questions. You Should Answer **ALL** the questions.
- Write clearly legibly with a blue or black pen.
- Use only the **CINEC Answering Booklet**. Additional sheets may be requested from the invigilators.
- This paper contains **8** pages.

MATERIALS REQURIED

- CINEC answering Booklet; Extra answering paper & Data sheets.
- You may use a scientific calculator. This must not be programmable. This may be examined during the examination.
- You may use additional data provided at the end of this examination paper (Data Sheet).

01.	Explain the history, layout and configuration of automobiles & explain the provisions of the Motor Traffic Act, and the current Emission Regulations			
	a.	Define the terms "Configuration" and "Layout" with respect to automobiles.	20%	100%
	b.	Study figure 1.  Figure 1		
		i. Identify the layout and the configuration of the depicted by figure 1.	10%	
		ii. Make a comment on advantages and the disadvantages of placing the power source of the automobile in the arrangement which is being depicted by figure 1.	20%	
	c.	Write a comparison between the 4WD systems and AWD systems.	30%	
		List down 5 main systems which can be found an Automobile.	20%	

02.	Describe the construction and operating principle of, systems, sub systems and main components of an automobile.			
	a.	Identify and name the components depicted by the numbers by referring the Figure 2 & 3.	30%	100%

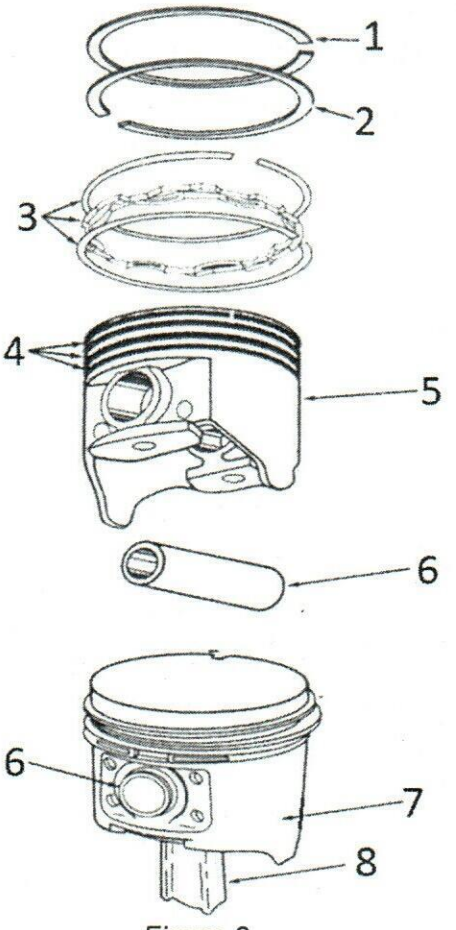


Figure 2

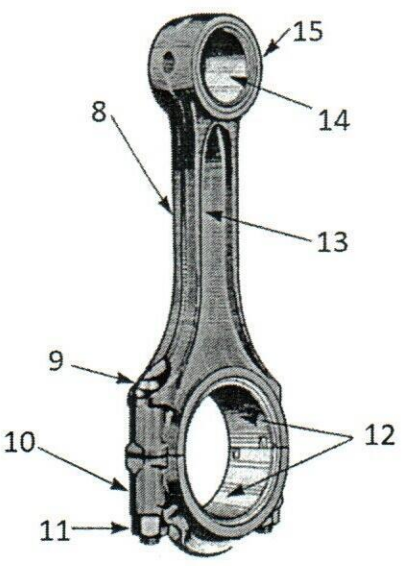


Figure 3

	b.	Identify and name the components depicted by the numbers by referring the Figure 4.	30%	

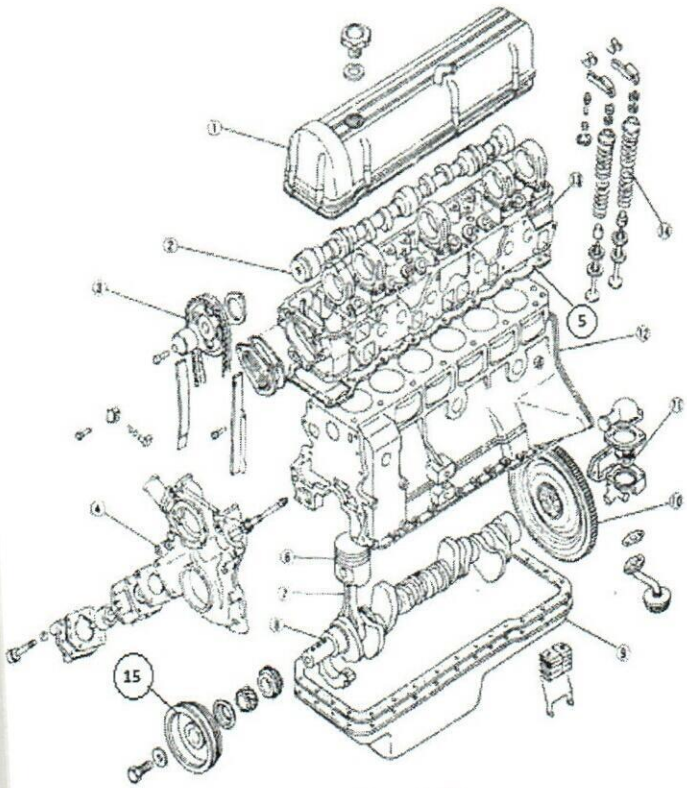


Figure 4

	c.	Identify and compare the types of pistons pins by referring the Figure 5.	20%	

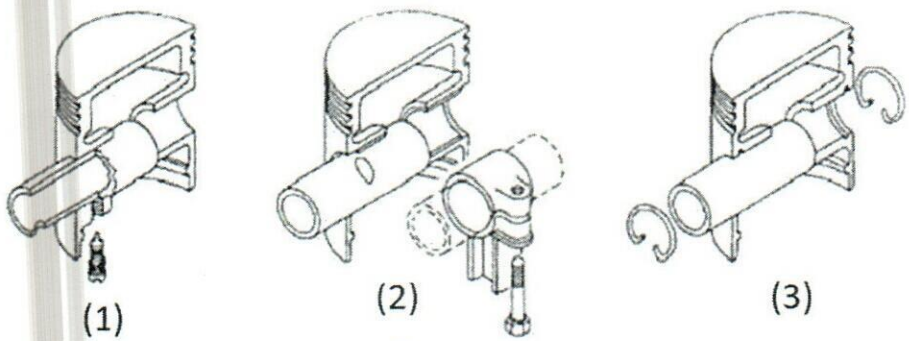
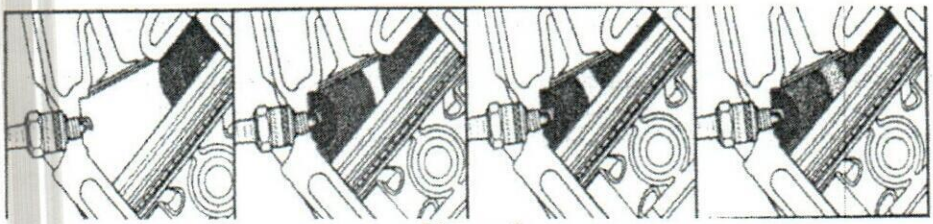
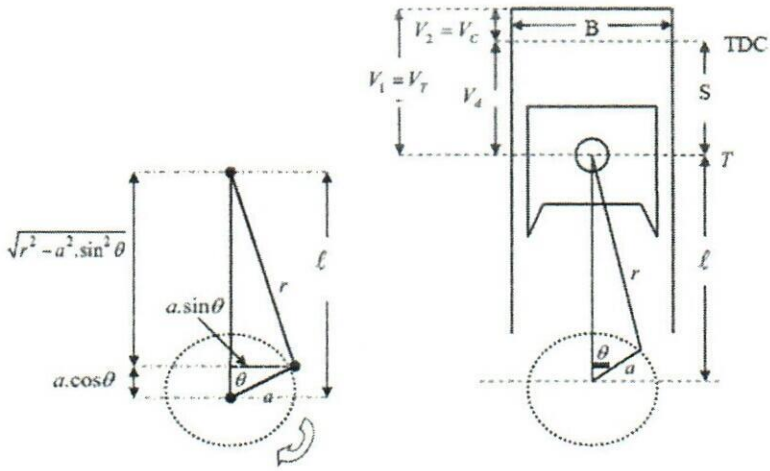


Figure 5

	d.	State 5 operations which are being carried out on a sand casted block after removing the cores.	20%	

03.	Explain the different types of fuels used in SI and CI engines and the respective combustion processes			
	a.	Point out the four main sources of air pollutants from the automobiles and how the volume of pollutants released to the environment from each source is being controlled by the vehicle emission system.	20%	100%
	b.	A sample of gasoline fuel is said to have an Octane Rating of 95.		
		i. Name the quality which is being governed by the Octane Rating of Gasoline.	5%	
		ii. Name the two types of reference fuels and their qualities which are being used in determining the octane rating of a produced sample of gasoline.	10%	
		iii. State the three test procedures which are being used in standard practice in determining the octane rating of a gasoline sample.	15%	
	c.	Identify the abnormal combustion condition which is depicted by figure 6 and write a short description of the occurrence (name, how it happens, why is happens, when it happens, issues it arises, causes) of the mentioned abnormal combustion.  *Figure 6*	20%	
	d.	Write short descriptions on the following, I. Stoichiometric Ratio II. Lean Combustion III. Rich Combustion		

04.	Perform calculations to determine engine performance parameters			
	a.	 *Figure 7* Show that the piston displacement for any given crank angle (θ) is given by, $l_{(\theta)} = a\cos\theta + \sqrt{r^2 - (a\sin\theta)^2}$	20%	100%
	b.	A 4G63t is a 1997cc inline four-cylinder turbocharged engine that operates on four stroke cycle @ 6,500 R.P.M. The compression ratio is 8.8:1, the length of a connecting rod is 156 mm, and the engine is square engine where B = S. Calculate the following considering S = 2a I. Cylinder Stroke Length II. Average Piston Speed III. The distance the piston has travelled @ $\theta = 45°$ (The distance between crank axis and the wrist pin axis)	25%	
	c.	An eight-cylinder four stroke automobile engine of 85.7mm bore and 82.5mm stroke with a compression ratio of 7 is tested at 4000 rounds per minute on a dynamometer which has a 0.5335m arm. During a 10-minute test at a dynamometer scale beam reading of 400N was read and a 4.55kg of gasoline with a heating value is 46,000kJ/kg were burnt. And air at 294K with 10×10^4 N/m^2 is supplied to the carburettor at the rate of 5.44kg per min. Determine the following, I. The brake power delivered. II. The brake means effective pressure. III. The brake specific fuel consumption. IV. The brake thermal efficiency.	25%	
	d.	The Following were recorded in the specification sheet of the RB26DETT 2.8L High Response 6 Cylinder four stroke gasoline engine by HKS.	30%	

Diameter	87.0mm
Stroke	77.7mm
Speed	9,000rpm
Displacement	2,771cc
HV	46,000 kJ/kg
Torque	784.532 Nm
Brake Power	581.7353 KW
Mechanical Efficiency	90%
Compression Ratio	8.6

	Calculate the following, I. Brake Power II. Indicated Power III. Indicated Mean Effective Pressure IV. Frictional Loss V. Compression Volume		

DATA SHEET

Equivalence Ratio	$\phi = \frac{A/F_{st}}{A/F}$
Lambda value(λ)	$\lambda = \frac{1}{\phi}$
Pythagorean Identity	$1 = \sin^2\theta + cos^2\theta$
The Displacement Volume	$d_p = \left(\frac{\pi}{4}\right) d^2 L$
Engine Capacity	$V_D = \left(\frac{\pi}{4}\right) B^2 S \times K = d_p \times K$
Average Piston Speed	$\overline{U_p} = \frac{2S * N}{60}$
Distance between the Wrist Pin Axis and the Main Journal Axis at a given Crank Angle	$l_{(\theta)} = acos\theta + \sqrt{r^2 - (a\sin\theta)^2}$
Brake Power	$BP = \left(\frac{2\pi TN}{60 \times 1000}\right)$
Mechanical Efficiency	$\eta_m = \frac{BP}{IP}$
Indicated Power for a Four Stroke Engine	$IP = \frac{P_i * LANK}{2 * 60{,}000}$
Frictional Power	$FP = IP - BP$
Brake Specific Fuel Consumption	$(BSFC) = \frac{60.W_f}{\mathrm{BP}}$
Fuel Flow Rate	$W_f = \frac{Amount\ of\ Fuel\ Delivered}{Time\ Period}$
Brake Thermal Efficiency	$\eta_B = \frac{60.\mathrm{BP}}{W_f.HV}$
Compression Ratio	$r = r_c = \frac{V_t}{V_c} = \frac{V_c + d_p}{V_c}$
Brake Mean Effective Pressure	$bmep = \frac{Bp * 2 * 60{,}000}{LANK}$
Indicated Mean Effective Pressure	$P_i = \frac{IP * 2 * 60{,}000}{LANK}$

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Faculty of Engineering & Technology

Department of Mechanical & Automotive Engineering

BSc Hons (Eng) in Mechanical Engineering

Semester 8 Re-sit Examination 2024

Module Code	:	**ME4324**
Module Title	:	**PRODUCTION ENGINEERING, PLANNING & CONTROL**
Date	:	**11th September 2024 from 1:30p.m. to 4:30p.m.**
Examiners	:	**Mr. Vijitha Abeysundera**
Time Allowed	:	**03 hours**

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- This paper consists of **05 questions**. You Should Answer **ALL** questions.
- Write clearly legibly with a blue or black pen.
- Use only the **CINEC Answering Booklet**. Additional sheets may be requested from the invigilators.
- This paper contains 12 pages.

MATERIALS REQURIED

- CINEC answering Booklet.
- You may use a scientific calculator. This must not be programmable. This may be examined during the examination.
- You may use additional data provided at the end of this examination paper

Question 1

(i) Discuss the importance steps in New Product Development Process **(20 marks)**

(ii) Distinguish the terms Market Driven and Technology Driven Approaches in Production Planning. **(20 marks)**

(iii) The Production Engineer is having two options as given below in one particular function of his production line.

(a) Through Automation

Investment Cost Rs. 10,000

Monthly variable cost of operating the system Rs. 100 (inclusive of all expenses)

Maximum volume that can be produced through automation process is 8000 units per year.

(b) Through Manually

Initial training cost Rs. 700

Monthly variable cost of operating Rs.700 (including salary and all other benefits)

Maximum volume that can be produced through automation process is 6000 units per year.

Advice the production engineer about the suitability of the options available to him. **(60 marks)**

Question 2

(i) Discuss the differences between Level Strategy and Chase Strategy in Aggregate Planning. **(30 Marks)**

(ii) 10 workers assigned to the production line, each capable of producing approximately 15 boats per month and each month has the same number of production days. Hiring and training cost of $400 per worker and layoff cost is $1,000 per worker. The production cost (labor, material, and overhead) is $300 per boat. Boat produced in overtime adds $60 in labor cost, and each worker can only produce an extra three boats per month using overtime. If they keep any boats in inventory it will cost them $6 per boat per month for any boat in inventory at the end of the month. The stockout cost of the company $120 in profit and currently have no boats in inventory. Using this simple data prepare the production plan to meet the demand given below. **(70 Marks)**

Table -1

Month	Jan	Feb	Mar	Apr	May	June
Demand	250	600	420	560	610	580

Question 3

(i) Explain the importance of Forecasting with regard to Production, Inventory and Human Resources **(20 marks)**

(ii) Discuss the importance of Delphi Method in forecasting. **(20 Marks)**

(iii) Briefly explain two shortcomings in Delphi Method. **(20 marks)**

(iv) Discuss the importance of Life Cycle Analysis in forecasting. **(20 Marks)**

(v) Distinguish the terms Moving Average and Weighted Moving Average method in Time Series Method. **(20 marks)**

Question 4

(i) Discuss the factors with suitable examples that you have to consider when selecting a suitable location to commence your new business venture. **(40 marks)**

(ii) Gold Pvt Limited is considering a new plant location for either City R or City S in addition to two existing factories in City P and City Q. Plants in P and Q are catering to warehouses in city A, B, C and D. The unit cost of transportation, the availability of goods and the requirements are given below.

Table-2

City of Origin	Transportation Costs per Unit to warehouses (Rs.)				Units Available
	A	B	C	D	
P	4	3	5	7	100
Q	5	8	5	2	150
R	3	6	2	4	100
S	2	7	3	2	100
Units Required	75	50	125	100	

a. Find the suitable location between R and S using North West Corner Rule (Initial Solution). **(60 marks)**

Question 5

(i) Discuss three key areas that you have to give due consideration when you are managing a maintenance program. **(30 marks)**

(ii) Activities involving complete overhaul of a gear box is given below with required time and predecessor events.

Question 3

(i) Explain the importance of Forecasting with regard to Production, Inventory and Human Resources **(20 marks)**

(ii) Discuss the importance of Delphi Method in forecasting. **(20 Marks)**

(iii) Briefly explain two shortcomings in Delphi Method. **(20 marks)**

(iv) Discuss the importance of Life Cycle Analysis in forecasting. **(20 Marks)**

(v) Distinguish the terms Moving Average and Weighted Moving Average method in Time Series Method. **(20 marks)**

Question 4

(i) Discuss the factors with suitable examples that you have to consider when selecting a suitable location to commence your new business venture. **(40 marks)**

(ii) Gold Pvt Limited is considering a new plant location for either City R or City S in addition to two existing factories in City P and City Q. Plants in P and Q are catering to warehouses in city A, B, C and D. The unit cost of transportation, the availability of goods and the requirements are given below.

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S	2	7	3	2	100
Units Required	75	50	125	100	

a. Find the suitable location between R and S using North West Corner Rule (Initial Solution). **(60 marks)**

Question 5

(i) Discuss three key areas that you have to give due consideration when you are managing a maintenance program. **(30 marks)**

(ii) Activities involving complete overhaul of a gear box is given below with required time and predecessor events.

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Faculty of Engineering & Technology
Department of Mechanical and Automotive Engineering
BSc Hons (Eng) Automotive Engineering / Mechanical Engineering / Mechatronics Engineering
Semester 4 First Sit Examination 2024

Module Code	:	**ME2325**
Module Title	:	**STRENGTH OF MATERIALS**
Date	:	**26th of July 2024**
Examiner	:	**Mr. Rashmika Wickrama**
Time Allowed	:	**3 Hours**

INSTRUCTIONS TO CANDIDATES

- This is a **closed-book** examination.
- This paper consists of **FIVE** questions. You Should Answer **ALL** the questions.
- Write clearly and legibly with a blue or black pen.
- Use only the **CINEC Answering Booklet**. Additional sheets may be requested from the invigilators.
- This paper contains 8 pages.

MATERIALS REQUIRED

- CINEC answering booklet, extra answering papers.
- You may use a scientific calculator. This must not be programmable. This may be examined during the examination.
- You may use additional data provided at the end of this examination paper (Data Sheet).

STUDENT NUMBER .....

Question 01

a) **Figure 1** shows a member that is subjected to two perpendicular direct stresses σ_1, σ_2, and a simple shear stress τ.

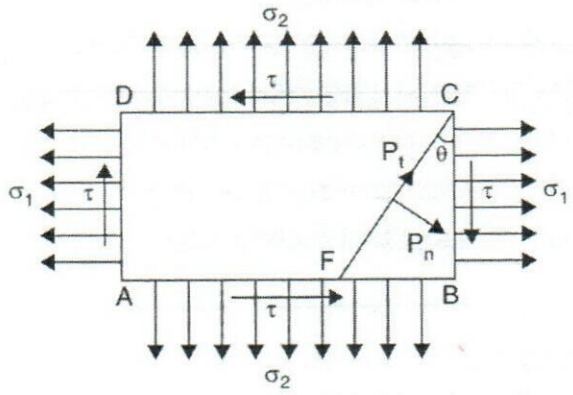


Figure 1

i. Derive the following formulas for the normal and tangential stresses of the FC plane. **40%**

$$\sigma_n = \frac{\sigma_1 + \sigma_2}{2} + \frac{\sigma_1 - \sigma_2}{2}\cos 2\theta + \tau \sin 2\theta$$

$$\sigma_t = \frac{\sigma_1 - \sigma_2}{2} \sin 2\theta - \tau \cos 2\theta$$

ii. Find the major and minor principal planes of the system. **20%**

40%

b) In a two-dimensional stress system, the direct stresses on two mutually perpendicular planes are 100 MN/m^2 and σ MN/m^2. These planes also carry a shear stress of 40 MN/m^2. If the factor of safety on the elastic limit is 2.5, then find the value of σ when shear strain energy is minimum.

Question 02

A cast iron beam of length 9 m is simply supported, carrying a uniformly distributed load of 10 kN/m length on the part of the span as shown in **Figure 2-a.** The cross-section of the beam is shown in **Figure 2-b**.

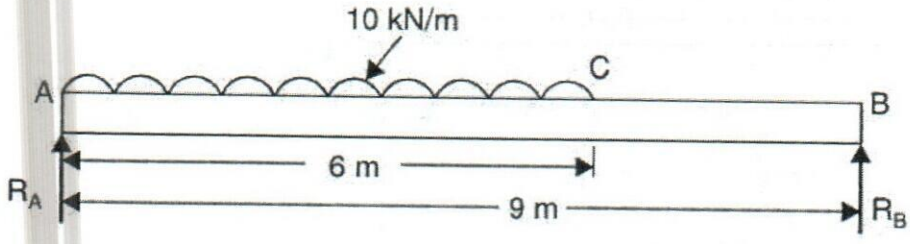


Figure 2-a

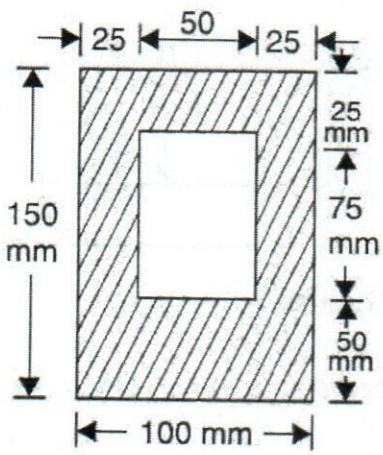


Figure2-b

i. Calculate the support reactions and draw the bending moment diagram of the beam neglecting the weight of the beam. **45%**

ii. Determine the maximum tensile and compressive stress induced in the beam. **55%**

Question 03

Figure 3 shows the I section of a beam with a depth of web d, the overall depth of section D, the thickness of web b, and the overall width of section B. The beam is subjected to a shear force F, at a section.

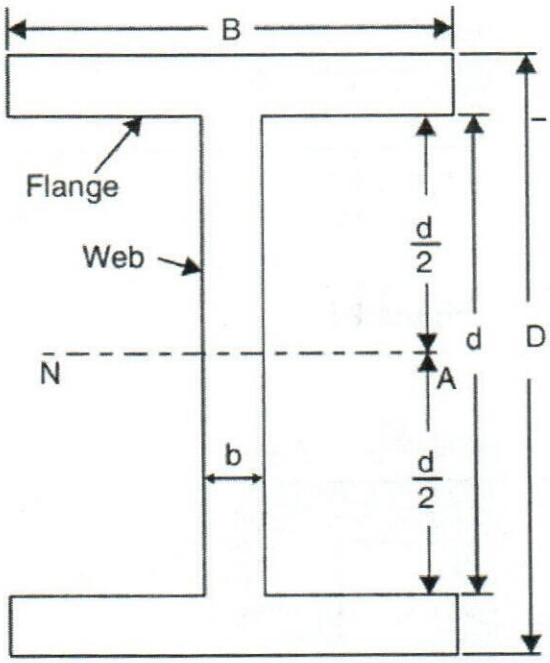


Figure 3

The shear stress at a distance y from the neutral axis is given by the following equation.

$$\tau = F\,\frac{A\,\bar{y}}{I\,b}$$

i. Develop the following equations to determine the shear stress distribution in the flange (τ_F) and the web (τ_W). **60%**

$$\tau_F = \frac{F}{2I}\left(\frac{D^2}{2} - y^2\right)$$

$$\tau_W = \frac{F}{Ib}\left[\frac{B}{8}(D^2 - d^2) + \frac{b}{2}\left(\frac{d^2}{4} - y^2\right)\right]$$

ii. Draw the shear force distribution diagram for the I section clearly showing the maximum shear stress and its location. **40%**

Question 04

a) A boiler is subjected to an internal steam pressure of 3 N/mm^2. The thickness of the boilerplate is 2.5 cm, the factor of safety is 3 and the ultimate tensile strength is 375 N/mm^2. Determine the maximum diameter, when the efficiency of the longitudinal joint is 90% and that of the circumferential joint is 35%. **50%**

b) A spherical vessel 1.5 m in diameter is subjected to an internal pressure of 2 N/mm^2. Determine the thickness of the plate required if maximum stress is not to exceed 150 N/mm^2 and joint efficiency is 75%. Determine the increase in volume of the vessel. Poisson's ratio is 0.5. **50%**

Question 05

a) An end-capped thick-walled cylinder with an internal radius of a and external radius of b is subjected to the internal pressure of P_i and external pressure of P_e. Determine the hoop stress σ_h, and radial stress σ_r, as a function of radial coordinate r using Lame's theorem. **50%**

$$\sigma_r = A - \frac{B}{r^2}$$

$$\sigma_h = A + \frac{B}{r^2}$$

Determine the axial stress σ_a for the above cylinder. **10%**

a) Determine the maximum and minimum hoop stress across the section of a pipe of 400 mm internal diameter and 100 mm thick, when the pipe contains a fluid at a pressure of 8 N/mm^2. Also, sketch the radial pressure distribution and hoop stress distribution across the section. Determine the required minimum yield strength of the material using the maximum principal stress theory if the safety factor is 3. **40%**

Formula Sheet

Stress transformation

$$\sigma_n = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta$$
$$\tau = \frac{\sigma_x - \sigma_y}{2}\sin 2\theta - \tau_{xy}\cos 2\theta$$

Strain transformation

$$\varepsilon_n = \frac{\varepsilon_x + \varepsilon_y}{2} + \frac{\varepsilon_x - \varepsilon_y}{2}\cos 2\theta + \frac{\gamma_{xy}}{2}\sin 2\theta$$
$$\frac{\gamma}{2} = \frac{\varepsilon_x - \varepsilon_y}{2}\sin 2\theta - \frac{\gamma_{xy}}{2}\cos 2\theta$$

Principal stress and orientation

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + {\tau_{xy}}^2}$$
$$\theta_n = \frac{1}{2}\tan^{-1}\left(\frac{2\tau_{xy}}{\sigma_x - \sigma_y}\right)$$

Principal strain and orientation

$$\varepsilon_{1,2} = \frac{\varepsilon_x + \varepsilon_y}{2} \pm \sqrt{\left(\frac{\varepsilon_x - \varepsilon_y}{2}\right)^2 + \left(\frac{\gamma_{xy}}{2}\right)^2}$$
$$\theta_n = \frac{1}{2}\tan^{-1}\left(\frac{\gamma_{xy}}{\varepsilon_x - \varepsilon_y}\right)$$

Constitutive equations

$$\varepsilon_x = \frac{1}{E}\left(\sigma_x - \nu(\sigma_y + \sigma_z)\right)$$
$$\varepsilon_y = \frac{1}{E}\left(\sigma_y - \nu(\sigma_x + \sigma_z)\right)$$
$$\varepsilon_z = \frac{1}{E}\left(\sigma_z - \nu(\sigma_x + \sigma_y)\right)$$
$$\sigma_x = \frac{E}{(1+\upsilon)(1-2\upsilon)}\left[(1-\upsilon)\varepsilon_x + \upsilon(\varepsilon_y + \varepsilon_z)\right]$$
$$\sigma_y = \frac{E}{(1+\upsilon)(1-2\upsilon)}\left[(1-\upsilon)\varepsilon_y + \upsilon(\varepsilon_x + \varepsilon_z)\right]$$
$$\sigma_z = \frac{E}{(1+\upsilon)(1-2\upsilon)}\left[(1-\upsilon)\varepsilon_z + \upsilon(\varepsilon_x + \varepsilon_y)\right]$$

Relationship between elastic constants

$$G = \frac{E}{2(1+\nu)}$$
$$K = \frac{E}{3(1-2\nu)}$$

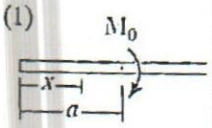
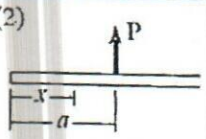
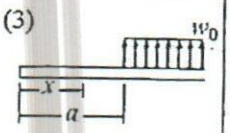
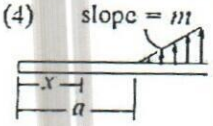
Flexure formula and shear formula for beams

$$\sigma = -\frac{My}{I}$$
$$\tau = V\frac{A'\overline{y'}}{It}$$

Bending moment function for beams

$$M(x) = EI\frac{d^2v}{dx^2}$$

Discontinuity functions for beams

Loading	Loading Function $w = w(x)$	Shear $V = \int w(x)dx$	Moment $M = \int Vdx$
(1) 	$w = M_0\langle x-a\rangle^{-2}$	$V = M_0\langle x-a\rangle^{-1}$	$M = M_0\langle x-a\rangle^{0}$
(2) 	$w = P\langle x-a\rangle^{-1}$	$V = P\langle x-a\rangle^{0}$	$M = P\langle x-a\rangle^{1}$
(3) 	$w = w_0\langle x-a\rangle^{0}$	$V = w_0\langle x-a\rangle^{1}$	$M = \frac{w_0}{2}\langle x-a\rangle^{2}$
(4) 	$w = m\langle x-a\rangle^{1}$	$V = \frac{m}{2}\langle x-a\rangle^{2}$	$M = \frac{m}{6}\langle x-a\rangle^{3}$

Torsion equation

$$\frac{T}{J} = \frac{\phi G}{L} = \frac{\tau}{\rho}$$

Euler's buckling equation

$$P_{cr} = \frac{\pi^2 EI}{(L_e)^2}$$

Lamé's equations

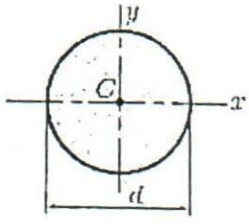
$$\sigma_r = A - \frac{B}{r^2}$$
$$\sigma_h = A + \frac{B}{r^2}$$

von Mises equivalent stress

$$\sigma_e = \frac{1}{\sqrt{2}}[(\sigma_1-\sigma_2)^2 + (\sigma_1-\sigma_3)^2 + (\sigma_2-\sigma_3)^2]^{\frac{1}{2}}$$

Geometric properties of a circular area

$$I_{xx} = I_{yy} = \frac{\pi d^4}{64}$$
$$J_C = \frac{\pi d^4}{32}$$

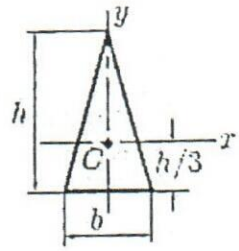


Geometric properties of a triangular area

$$I_{xx} = \frac{bh^3}{36}$$

$$I_{yy} = \frac{b^3 h}{36}$$

$$J_c = \frac{bh}{36}(b^2 + h^2)$$



Stresses induced in thin cylinders

Hoop stress $\sigma_1 = \frac{p\,d}{2\,t\,\eta_l}$

Longitudinal stress $\sigma_2 = \frac{p\,d}{4\,t\eta_c}$

Stress-induced in thin spherical cells

$$\sigma_1 = \frac{p\,d}{4\,t}$$

Volumetric Strain in thin spherical cells

$$Volumetric\ Strain = \frac{3pd}{4Et}\,[1 - \nu]$$

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CINEC Campus
Faculty of Engineering & Technology
Department of Mechanical & Automobile Engineering
BSc Hons (Eng) In Mechanical Engineering &
BSc Hons (Eng) In Automobile Engineering
Semester 4 First Sit Examination 2024

Module Code	:	**ME2324**
Module Title	:	**AUTOMOBILE TECHNOLOGY II**
Date	:	**31ST OF JULY 2024**
Examiners	:	**WASABHA Y SAMARATHUNGA**
Time Allowed	:	**03 hrs.**

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- This paper consists of **FOUR** questions. You Should Answer **ALL** the questions.
- Write clearly legibly with a blue or black pen.
- Use only the **CINEC Answering Booklet**. Additional sheets may be requested from the invigilators.
- This paper contains **9** pages.

MATERIALS REQURIED

- CINEC answering Booklet; Extra answering paper & Data sheets.
- You may use a scientific calculator. This must not be programmable. This may be examined during the examination.
- You may use additional data provided at the end of this examination paper (Data Sheet).

(01)	Describe the construction and operating principle of transmission systems in automobiles			
I.	a.	Note down the three main functions of the Clutch.	9%	25%
	b.	Identify the components depicted by the Figure 1 & Figure 2.	16%	

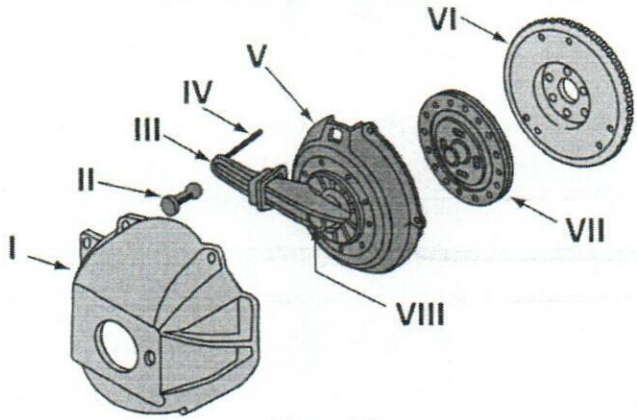


Figure 1

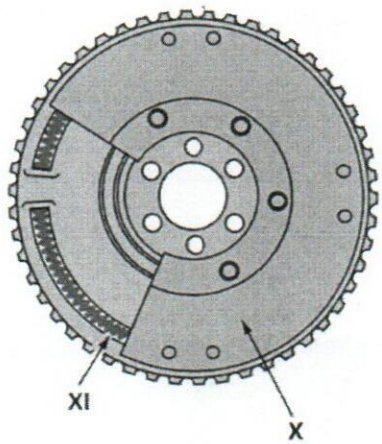


Figure 2

II.	a.	Justify the necessity on a Transmission or and Transaxle to be present in a vehicle.	6%	30%
	b.	Identify the components depicted by the Figure 3.	24%	

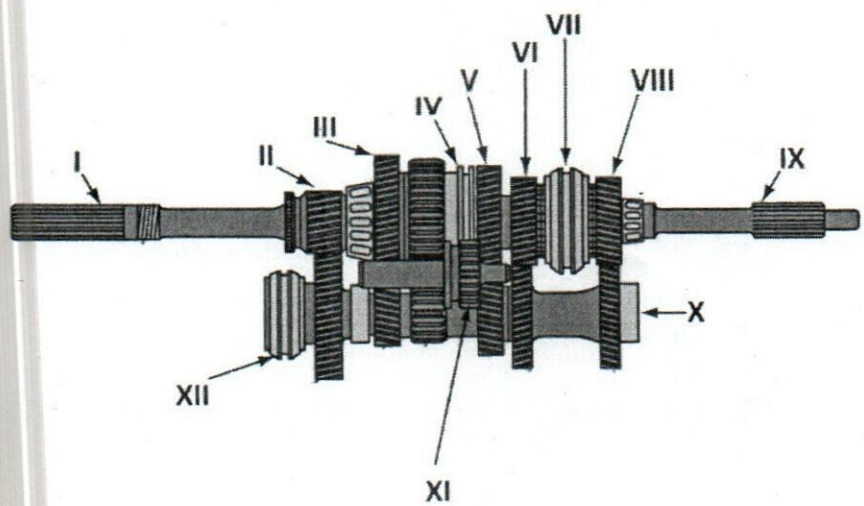


Figure 3

III.	Discuss the working principle of the torque converter by referring the Figure 4.			20%

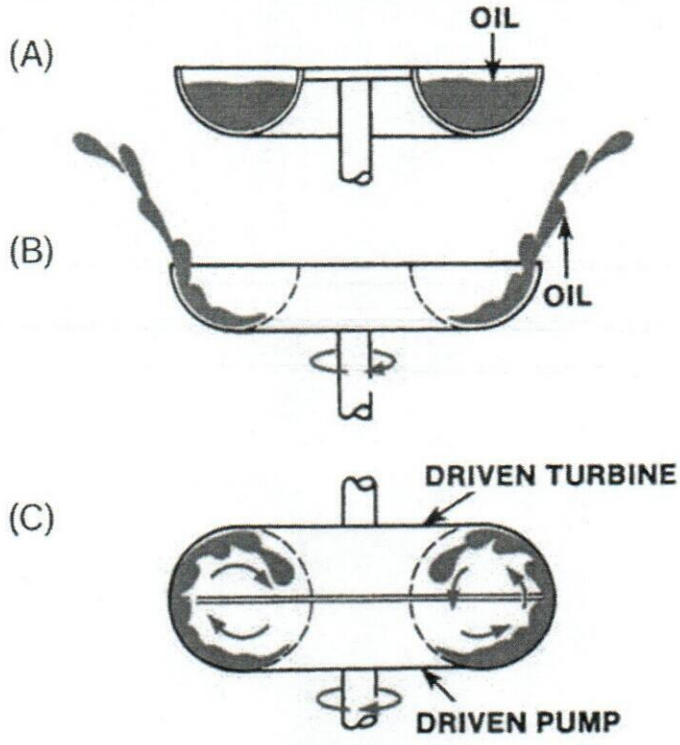


Figure 4

IV.	a.	List out the main components which can be found in a Simple Planetary Gear Set.	5%	25%
	b.	List down the two types of Planetary Gear Control Systems available in Automatic Transmission Boxes.	5%	
	c.	Mention key capability the automatic transmission clutches possess or transmission Bands.	5%	
	d.	Explain the working principle of the Transmission box depicted by the Figure 5.	10%	

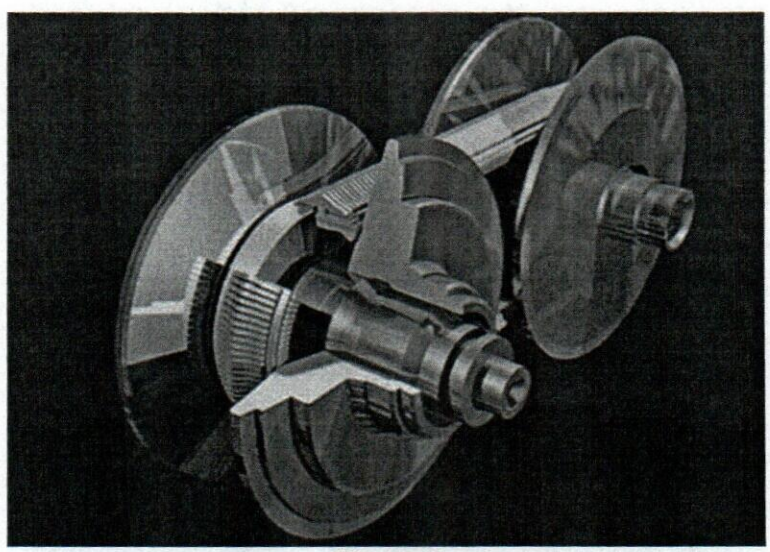


Figure 5

(02)	Describe the construction and operating principle of suspension systems in automobiles				
	I.	a.	Note down five functions of the Suspension System.	10%	25%
		b.	Identify and explain the phenomenas depicted by the Figure 6 and Figure 7.	15%	

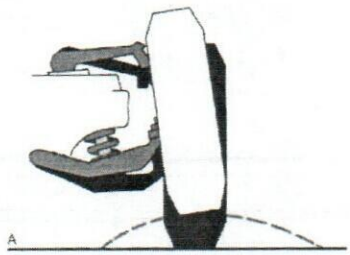


Figure 6

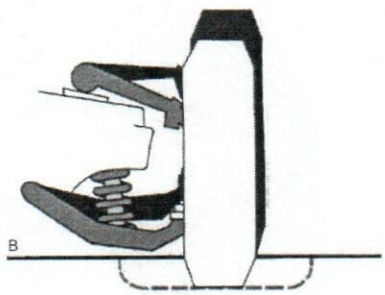


Figure 7

	II.	a.	Identify the components depicted by the Figure 8.	20%	25%

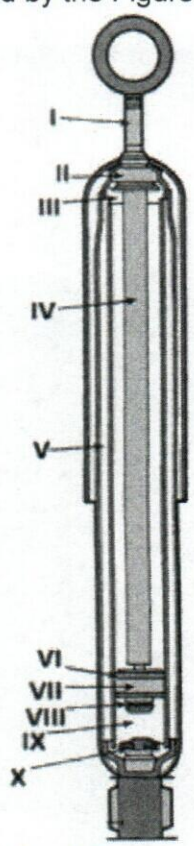


Figure 8

		b.	Name the two main types of shock absorbers available in the industry.	5%	

III. Go through the Figure 09. 25%

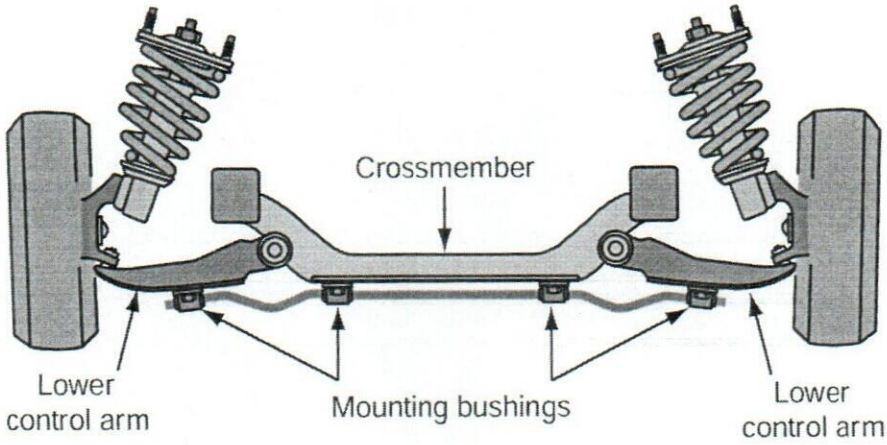


Figure 9

a.	Identify the component which is mounted to the crossmember and the lower control arms by using mounting bushings.	5%
b.	Mention the main role of the component which is mounted to the crossmember and the lower control arms by using mounting bushings.	10%
c.	Describe how the component which is mounted to the crossmember and the lower control arms by using mounting bushings acts if both the wheels go into a jounce & if only one wheel goes into a jounce.	10%

IV. Go through the Figure 10. 25%

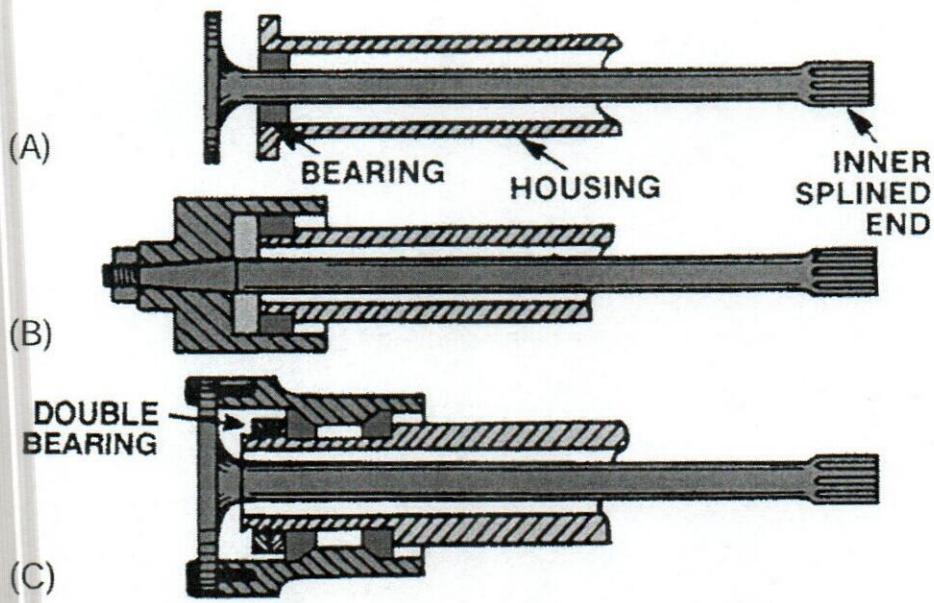
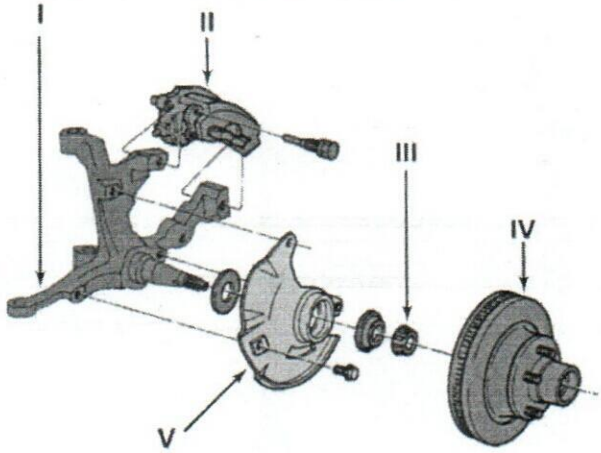
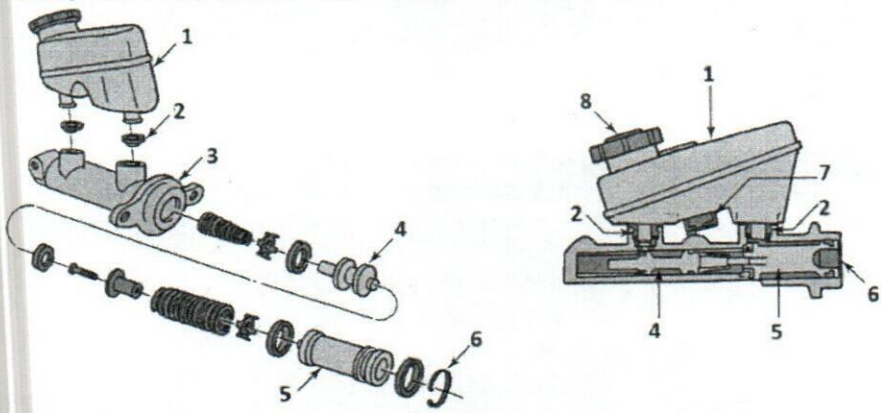
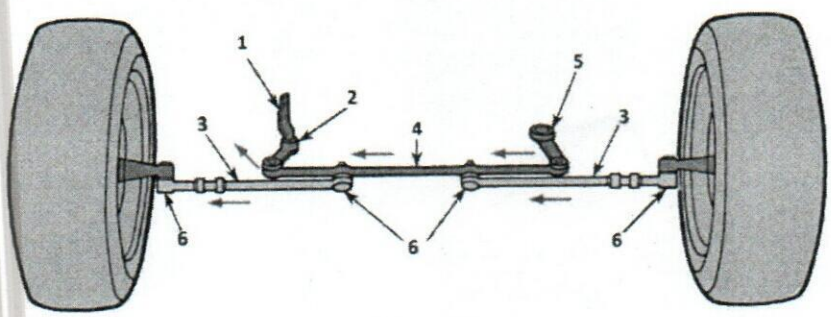


Figure 10

a.	Name the types of Axles depicted by the Figure 10.	10%
b.	Differentiate of Axles depicted by the Figure 10.	15%

(03)	Describe the construction and operating principle of braking and steering systems in automobiles				
	I.	a.	Identify the components depicted by the Figure 11.	10%	25%
			 *Figure 11*		
		b.	Explain the theory behind braking considering both the moving and stationery situations of an automobile using the conservation of energy.	15%	
	II.	a.	Note down the four factors affecting braking.	5%	25%
		b.	Note down the two types of Splits available in Braking Systems.	4%	
		c.	Identify the components depicted by the Figure 12.	16%	
			 *Figure 12*		
	III	a.	Note down the purpose of the steering system.	5%	25%
		b.	Identify the components depicted by the Figure 13	12%	
			 *Figure 13*		
		c.	Define the term Steering Linkage.	5%	
		d.	Note down the main purpose of the Steering Linkage.	3%	

IV.	a.	Describe the working principle of the steering rack.	10%	25%
	b.	Identify the components depicted by the Figure 14.	10%	

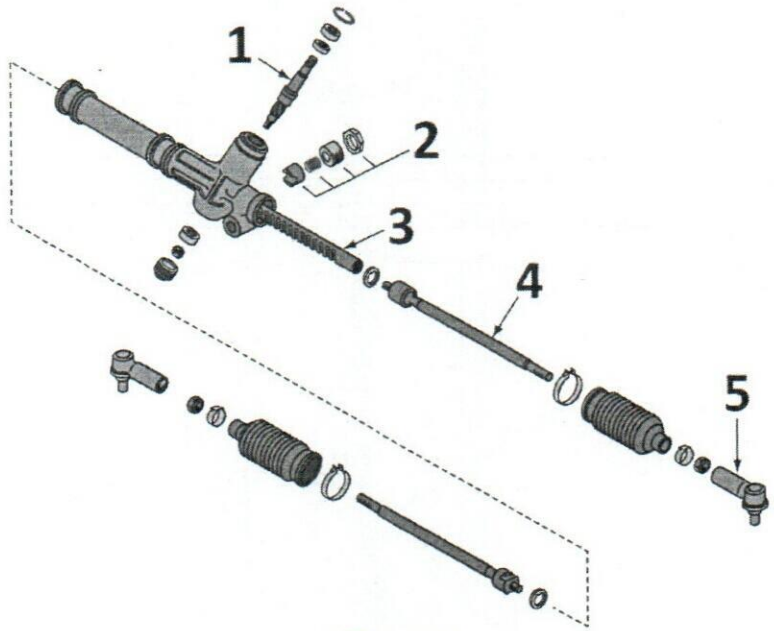
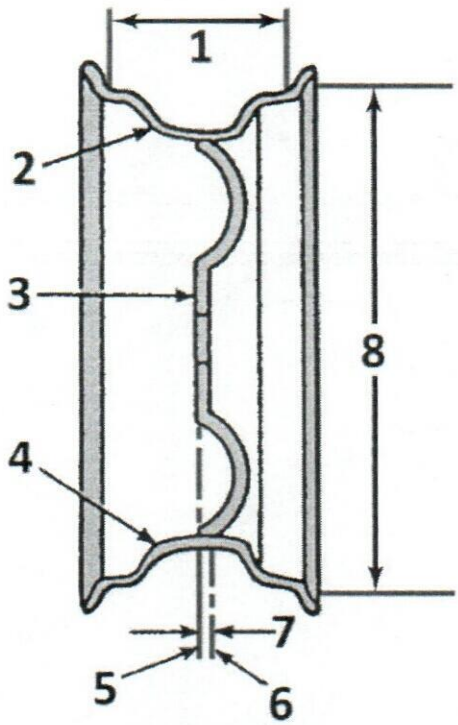
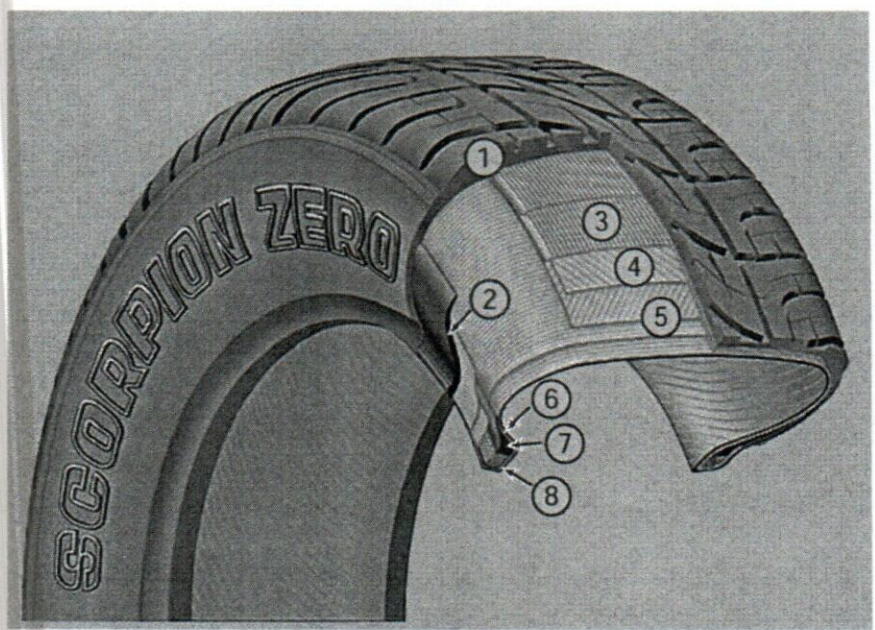
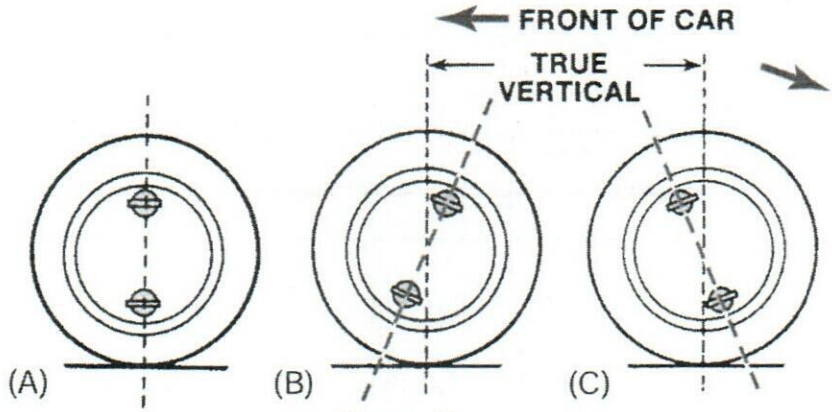
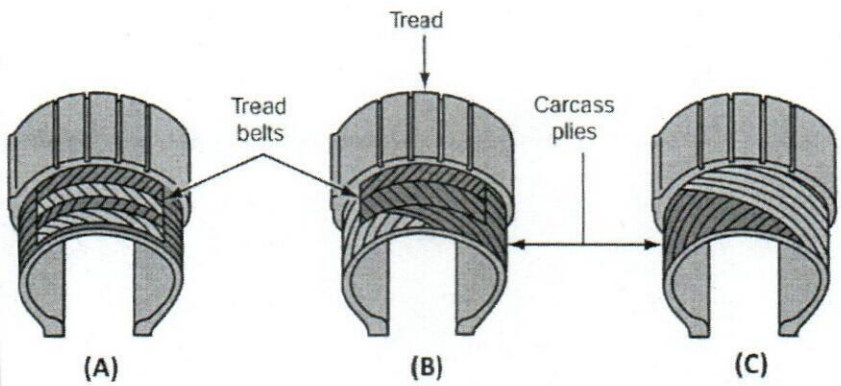


Figure 14

	c.	Note down the two main types of Power Steering Systems	5%	

(04) Describe the construction and operating principle of tyres for automobiles

I.	a.	Identify the components depicted by the Figure 15.	16%	25%
		 *Figure 15*		
	b.	Explain what is defined by Number 7 depicted in the Figure 15.	9%	
II.	a.	Identify the components depicted by the Figure 16.	16%	25%
		 *Figure 16*		
	b.	Identify what is meant by each of the notations of the following piece of information printed on the tyre sidewall. P 205 / 75 R 15	9%	

	III.	a.	Define what is meant by wheel alignment and the principle followed when carrying out a wheel alignment service.	12.5%	25%
		b.	Identify and define the wheel alignment angle depicted by the Figure 17.  *Figure 17*	12.5%	
	IV.	a.	Identify and define the different types of tyre ply constructions depicted by the Figure 18.  *Figure 18*	21%	25%
		b.	List down the four types of tread patterns available.	4%	