

Time : 3 hours

Full Marks : 200

Instructions :

- (1) Answer any **ten** questions following directions.
- (2) The figures in the margin indicate full marks for the questions.
- (3) Use of programmable devices or graphical calculator is NOT allowed.

1. (a) State the Lami's theorem for the equilibrium of a rigid body under the action of three coplanar forces. A simple stone-crushing mechanism consists of a piston on which a force of 15 kN acts and three rigid weightless links OA, OB and OC hinged at O, A, B and C as shown in Fig. 1. At the given orientation, what is the force exerted on the stone S trapped between the jaw and the fixed wall? 2+6=8

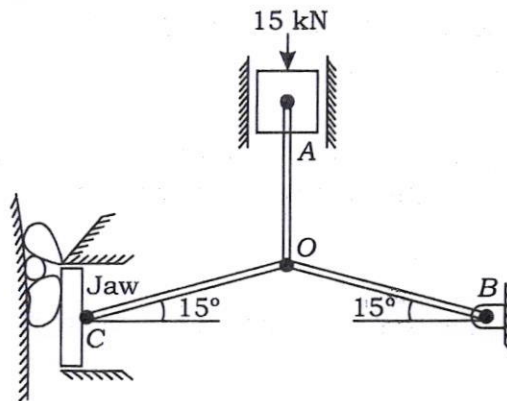


Fig. 1

- (b) What are statically determinate and statically indeterminate systems? Give one example of each such system. 2+2=4
- (c) A string carrying a weight of 15 kg is tied to a ceiling and passed over three pulleys A, B and C as arranged in Fig. 2 (a). Find the acceleration of the 25 kg mass suspended from the pulley A as shown in Fig. 2 (a). If the 15 kg mass is removed and a tension of (15×9.81) N is applied to the string as shown in Fig. 2 (b), will the acceleration

of the 25 kg mass be changed? If it is so then by how much the acceleration is changed?

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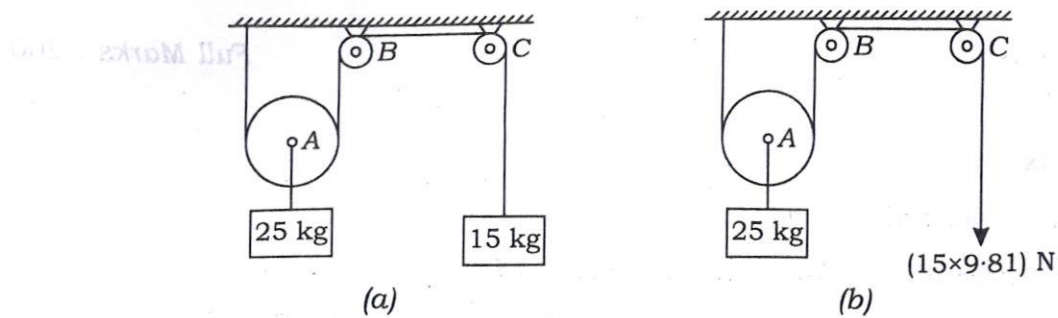


Fig. 2

2. (a) What is a mechanism and a machine? Give examples of each. $2+2=4$
- (b) What do you mean by inversion of a mechanism? Describe various inversions of a slider-crank mechanism giving examples. $2+8=10$
- (c) State the fundamental law of gearing. Name two common forms of teeth that satisfy the law of gearing. $2+2=4$
- (d) A standard gear has outside diameter of 100 mm and module 4 mm. Evaluate the number of teeth on the gear. 2
3. (a) What is the function of a governor? How does it differ from that of a flywheel? $2+2=4$
- (b) What are inertia governors? How do they differ from centrifugal governors? $2+2=4$
- (c) What is the condition of isochronism in governors? In what type of governors can it be achieved? Find the required condition of isochronism in case of a Hartnell governor. $2+2+4=8$
- (d) What do you understand by balancing of machines? What is the condition for dynamic balancing of a shaft-rotor system? $2+2=4$

4. (a) What is vibration? Write down the constitutive law for the following basic elements of a vibratory system : 2+4=6

Linear spring, Linear viscous damper

- (b) What do you mean by degrees of freedom of a vibratory system? In a three-dimensional space, what are the degrees of freedom of a particle and that of a rigid body? 2+2=4

- (c) What are the causes of vibration? How does it affect the performance of a machine? Discuss different remedial measures to reduce vibration. 4+2+4=10

5. (a) The Mohr's circle for a plane stress is a circle of radius R with its origin at $+3R$ on σ axis. Sketch the Mohr's circle and determine σ_{\max} , σ_{\min} and $(\tau_{xy})_{\max}$ for this situation. 5

- (b) Write the generalized Hooke's law for a stressed body as shown in Fig. 3 : 3

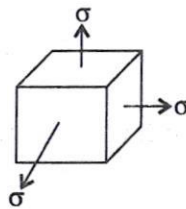


Fig. 3

- (c) A solid shaft and a hollow shaft of same material have the same length and same outer radius R . The inner radius of the hollow shaft is $0.7R$. If both the shafts are subjected to the same torque, then compare their shear stresses, angle of twist and weights. Also, find the strength to weight ratio for both shafts. 3+3+3=9

- (d) Define section modulus. What is its physical significance? 1+2=3

6. (a) Represent the basic machining operation with the help of a schematic diagram showing all important parameters. 6

- (b) What is machinability? Explain the major criteria for judging machinability. $2+6=8$
- (c) How are grinding wheels specified? Clearly differentiate between grade and structure of a grinding wheel. $4+2=6$
7. (a) What is metal forming? Classify the metal forming processes with examples. $2+4=6$
- (b) Explain the extrusion process with the help of a schematic diagram. Give the example of two extruded products. $6+2=8$
- (c) What is the principle of gas welding? Name different types of oxy-acetylene flames. $3+3=6$
8. (a) Explain the term 'break-even point'. State different methods for computing the break-even point. $3+5=8$
- (b) What is work study? What is the basic tool in work study? $2+1=3$
- (c) What is sequencing? What is the importance of sequencing in industries? $2+2=4$
- (d) How many total therbligs are there in the Gilberth's micro-motion study? Mention four important therbligs with symbols. $1+4=5$
9. (a) What is zeroth law of thermodynamics? What are the ordinary and absolute temperature scales in the SI and the English system? Is absolute gas temperature scale a thermodynamic temperature scale? If not, why? $2+2+1=5$
- (b) A new temperature scale $^{\circ}\text{N}$ is divided in such a way that the freezing point of ice is 100°N and the boiling point is 400°N . What is the temperature reading on this new scale when the temperature is 150°C ? At what temperature both the Celsius and the new temperature scale reading would be the same? $5+1=6$

- (c) What is the difference between (i) saturated and compressed liquid and (ii) saturated and superheated vapour? 2+2=4
- (d) What is a steady flow process? Write down the general steady flow energy equation (SFEE). How does the SFEE get modified when it is applied to a steam turbine? 2+2+1=5
10. (a) What is a thermal energy reservoir? Give two examples. 2+2=4
- (b) What is Kelvin-Planck statement of the second law of thermodynamics? Does a heat engine that has a thermal efficiency of 100% necessarily violate (i) the first law and (ii) the second law of thermodynamics? Explain. 2+3=5
- (c) What is the difference between a refrigerator and an air-conditioner? In a refrigerator, heat is transferred from a low temperature medium (refrigerated space) to a high temperature one. Is this a violation of the second law of thermodynamics? Explain. 3+3=6
- (d) How can we increase the COP of a Carnot refrigerator? What is the highest COP that a refrigerator operating between temperature levels T_L and T_H can have? 3+2=5
11. (a) What is second law of efficiency? How does it differ from the first law of efficiency? 2+2=4
- (b) What is a reversible process? What are the causes of irreversibility? How is irreversibility related with entropy generation? Is a process during which no entropy is generated ($S_{\text{gen}} = 0$) necessarily reversible? 2+2+2+1=7
- (c) Why is Carnot cycle not suitable as an ideal cycle for all power producing cyclic devices? Explain with the help of T - s diagram of a Rankine cycle. 5
- (d) What does the area enclosed by any thermodynamic cycle represent on p - V diagram? How about on a T - s diagram? 2+2=4

12. (a) What is the difference between clearance volume and displacement volume of a reciprocating engine? Define the terms compression ratio and mean effective pressure. 2+2+2=6
- (b) How does a diesel engine differ from a petrol engine? For a specified compression ratio, is a diesel or a petrol engine more efficient? 4+2=6
- (c) What four processes make up the simple ideal Brayton cycle? 4
- (d) For fixed maximum and minimum temperatures, what is the effect of pressure ratio on (i) the thermal efficiency and (ii) the network output of a simple ideal Brayton cycle? 4
13. (a) What is absorption refrigeration? How does an absorption refrigeration system differ from a vapor compression refrigeration system? Explain with the help of schematics. 1+6=7
- (b) What is dew-point temperature? How is the dew-point temperature at a specified state determined on the psychrometric chart? In summer, the outer surface of a glass filled with iced water frequently sweats. How can you explain this sweating? 2+1+2=5
- (c) What is the difference between specific humidity and relative humidity? 4
- (d) How do relative and specific humidities change during a simple heating process? Answer the same question for a simple cooling process. 2+2=4
14. (a) During a regeneration process, some steam is extracted from the turbine and is used to heat the liquid water leaving the pump. This does not seem like a smart thing to do since the extracted steam could produce some more work in the turbine. How do you justify this action? 4
- (b) What is the difference between cogeneration and regeneration? Draw the schematic of a steam power plant with one open water heater and one closed water heater. Also draw the corresponding T-s diagram. 2+4+2=8

- (c) In a combined gas steam cycle, what is the energy source for the steam? Why is the combined cycle more efficient than either of the cycles operated alone? 1+3=4
- (d) What is a binary power cycle? What is the difference between a binary vapour power and a combined cycle? 2+2=4
15. (a) Name different types of turbines used in power plants. How is the water turbine classified? 2+3=5
- (b) What is the basic difference between an impulse and a reaction turbine? What do you mean by degree of reaction? 5
- (c) Explain the working principle of a centrifugal pump with the help of a proper diagram. 5
- (d) How is a reciprocating pump different from that of a centrifugal pump? Compare them in terms of head *vs.* flow rate characteristics. 3+2=5

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