

Date : October 11, 2025
Total Marks : 100
Writing Time : 150 minutes (2.5 hours)
Reading Time : 15 Minutes (prior to writing time)

1. Write your Registration Number clearly and correctly on the Answer Booklet.
2. The first 15 minutes is to check the number of pages of Question Paper, printing errors, clarify doubts and to read the instructions. You are NOT permitted to write during this time.
3. This paper consists of **TWO SECTIONS**, namely SECTION A & SECTION B:
 - **SECTION A** has two parts:
 - Part I - 30 Multiple Choice Questions
 - Part II - 4 Short Answer QuestionsAll questions under SECTION A are **COMPULSORY**.
 - **SECTION B** consists of two Case Studies. Choose only **ONE** case study and answer the questions of your choice.
4. All answers should be written on the Answer Booklet provided to you. Candidates are not allowed to write anything on the question paper. If required, ask for additional Answer Booklet.
5. All answers should be written with correct numbering of Section, Part and Question Number in the Answer Booklet provided to you. Note that any answer written without indicating the Section, Part and Question Number will NOT be evaluated and no marks will be awarded.
6. Begin each Section and Part in a fresh page of the Answer Booklet.
7. You are not permitted to tear off any sheet(s) of the Answer Booklet as well as the Question Paper.
8. Use of any other paper including paper for rough work is not permitted.
9. **You must hand over the Answer Booklet to the Invigilator before leaving the examination hall.**
10. This paper has **8 printed pages**, including this instruction page.

Page 1 of 8

SECTION A

PART I: Multiple Choice Questions [30 marks]

Choose the correct answer and write down the letter of your chosen answer in the Answer Booklet against the question number e.g. 31 (d). Each question carries ONE mark. Any double writing, smudgy answers or writing more than one choice shall not be evaluated.

1. If two shafts are made of same materials and diameter of one shaft is half of the other, power transmitted by the larger diameter shaft will be _____ of the smaller shaft.
 - a) 16 times
 - b) 8 times
 - c) 4 times
 - d) 2 times

2. A steel with 0.8 per cent carbon is known as
 - a) eutectoid steel
 - b) hypoeutectoid steel
 - c) hypereutectoid steel
 - d) proeutectoid steel

3. _____ is not suitable for plastic materials.
 - a) Laser Beam Machining
 - b) Ultrasonic Machining
 - c) Abrasive Jet Machining
 - d) Electric Discharge Machining

4. As per _____, “if three plane bodies have relative motion among them, their instantaneous centres must lie on a straight line”.
 - a) Pappus-Leisenring Theorem
 - b) Saint Venant’s Principle
 - c) D’Alembert’s Principle
 - d) Kennedy’s Theorem

5. Choose the *false* statement from the following.
 - a) The term jig is used for devices employed for operations such as milling and shaping while fixture is used if the operations are drilling and reaming.
 - b) Fixtures hold the work during machining operation.
 - c) Jigs limit and control the path of the cutting tool.
 - d) Fixtures are fixed to machines while jigs are not.

6. Cutting force (F) in sheet metal piercing is calculated as:

a) $F = \frac{S \times t}{p}$

b) $F = \frac{S \times t}{t}$

c) $F = \frac{p \times t}{s}$

d) $F = S \times p \times t$

where “S” is shear strength of the stock material, “p” is perimeter or length of cutting edge and “t” is thickness of material.

7. In the case of _____, axial thrust is minimal:

a) Pure action turbine

b) Francis turbine

c) Pelton turbine

d) Kaplan turbine

8. For a Poisson’s ratio of 0.25, ratio of modulus of rigidity to bulk modulus would be:

a) $\frac{1}{5}$

b) $\frac{2}{5}$

c) $\frac{3}{5}$

d) 1

9. The torque developed by a disc clutch is given by

a) $T = 0.25\mu WR$

b) $T = 0.5\mu WR$

c) $T = 0.75\mu WR$

d) $T = \mu WR$

where W = Axial force with which the friction surfaces are held together,

μ = Coefficient of friction; and

R = Mean radius of friction surfaces.

10. In maintenance engineering, MTTF stands for

a) Maximum Time To Failure

b) Mean Time To Failure

c) Median Time To Failure

d) Minimum Time To Failure

11. Efficiency of self-locking or overhauling screw is

a) =50% or <50% respectively

b) < 50% or >50% respectively

c) >50% or <50% respectively

d) $>50\%$ or $=50\%$ respectively

12. In _____, molten metal is forced into a permanent metal mould under pressure.

- a) Centrifugal casting
- b) Die casting
- c) Slush casting
- d) Permanent mould casting

13. The product of diametral pitch and circular pitch in spur gear is equal to:

- a) Number of teeth $\times \pi$
- b) π
- c) $\frac{1}{\pi}$
- d) 1

14. If a shaft revolves at 120rpm, its angular velocity is

- a) 12.57 meter per second
- b) 12.57 rpm
- c) 12.57 radian per second
- d) 12.57 degree

15. If the pressure difference between the inside and outside of a soap bubble of 5mm diameter is 10 N/m^2 , the surface tension is:

- a) $12.5 \times 10^{-3} \text{ N/m}$
- b) $12.5 \times 10^{-2} \text{ N/m}$
- c) $12.5 \times 10^{-1} \text{ N/m}$
- d) 125 N/m

16. Two shafts A and B are made of same materials and the diameter of shaft A is twice as that of shaft B. If shaft A can transmit 1MW of power, shaft B can transmit a power of:

- a) 1MW
- b) 2MW
- c) 4MW
- d) 6MW

17. The failure of 10 parts out of every 1000 parts manufactured represents a reliability of:

- a) 0.090
- b) 0.990
- c) 9.90
- d) 990

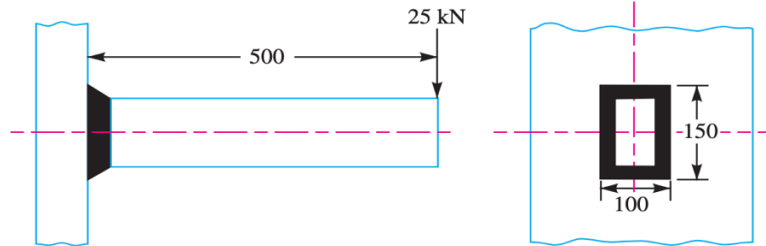
18. Tolerance grade for a hole and a shaft of 8 and 7 respectively is represented as:
- a) H8/G7
 - b) h8/g7.
 - c) H8/g7
 - d) h8/G7
19. Addition of _____ improves machinability of steel
- a) Manganese and tin
 - b) Nickel and chromium
 - c) Sulphur, lead and phosphorus
 - d) Carbon and copper
20. Two non-parallel, intersecting shafts are connected by:
- a) Grooved Joint
 - b) Hooke Joint
 - c) Hinge Joint
 - d) Flanged Joint
21. The time of flight (t) of a projectile on an upward inclined plane is given by:
- a) $t = \frac{g \cos \beta}{2u \sin(\alpha + \beta)}$
 - b) $t = \frac{2u \sin(\alpha + \beta)}{g \cos \beta}$
 - c) $t = \frac{2u \sin(\alpha - \beta)}{g \cos \beta}$
 - d) $t = \frac{g \cos \beta}{2u \sin(\alpha - \beta)}$
- Where u = Velocity of projection, α = Angle of projection, and β = Inclination of the plane with the horizontal.
22. In automation, actuators
- a) Sense the environment
 - b) Convert electrical signals into mechanical movement
 - c) Process data
 - d) Control the flow of data
23. The type of gear is used to transmit power between non-parallel, intersecting shafts is
- a) Bevel Gear
 - b) Helical Gear
 - c) Spur Gear
 - d) Worm Gear

24. Which of the following is responsible for removing heat from the refrigerant in a refrigeration cycle?
- a) Evaporator
 - b) Compressor
 - c) Condenser
 - d) Expansion Valve
25. The most common firing order for a 4-cylinder inline engine is:
- a) 1-3-4-2
 - b) 1-2-3-4
 - c) 1-3-2-4
 - d) 1-4-3-2
26. Film friction is said to occur:
- a) when two surfaces in contact are completely unlubricated surfaces.
 - b) When two surfaces in contact have a minute thin layer of lubricants.
 - c) When two surfaces in contact are completely separated by lubricants.
 - d) When two surfaces in contact are completely separated by air.
27. In CNC programming, G-codes are used to:
- a) Prepare a machine to engage in a particular mode for machining
 - b) Turn the machine on and off.
 - c) Control the flow of coolant
 - d) Control spindle
28. A cylinder is known as thin:
- a) if the ratio of its inner diameter to the wall thickness is less than 15.
 - b) if the ratio of its inner diameter to the wall thickness is more than 15.
 - c) if the ratio of its inner diameter to the wall thickness is less than 1.
 - d) if the ratio of its inner diameter to the wall thickness is more than 1.
29. Single cylinder engines are generally
- a) Oil cooled.
 - b) Air cooled.
 - c) Not required to be cooled
 - d) Water cooled
30. The temperature of air recorded by a thermometer, when the moisture present in it begins to condense is called:
- a) Dry bulb temperature
 - b) Wet bulb temperature
 - c) Dew point temperature
 - d) Saturation temperature

PART II – Short Answer Questions [20 marks]

This part has 4 Short Answer Questions. Answer ALL the questions. Each question carries 5 marks. Mark for each sub-question is indicated in the brackets.

1. A rectangular cross-section bar is welded to a support by means of fillet welds as shown in the following figure. Determine the size of welds, if the permissible shear stress in the weld is limited to 75 MPa. **(5 marks)**



2. Explain the differences among heat engine, refrigerator and heat pump with the help of a schematic diagram. Provide an expression to calculate the coefficient of performance for each of them. **(5 marks)**
3. Answer the following.
 - a. Define productivity in view of manufacturing production system? **(2 marks)**
 - b. A firm manufactures certain type of product. The standard time per piece is 1.5 minutes. The output of the firm is 300 units per shift of 8 hours.
 - i. What is the productivity of the firm per shift of 8 hours? **(1.5 marks)**
 - ii. What is the production of the firm per week (considering 6 working days) if the firm performs double shift every day? **(1.5 marks)**
4. Based on the following data pertaining to a proposed hydropower plant site, determine:
 - a. Power generation potential **(2.5 marks)**
 - b. Suggest the type of turbine to be used if runner speed is to be kept below 240rpm. **(2.5 marks)**

Data: Available head=140m, catchment area=2000KM², average annual rainfall=145cm, turbine efficiency=85%, generator efficiency=90%, percolation and evaporation losses=16%.

SECTION B: CASE STUDY [50 marks]

Choose either CASE I OR CASE II from this section. Each case study carries 50 marks.

CASE I

1. A refrigerating machine of 6 tonnes capacity working on Bell-Coleman cycle has an upper limit pressure of 5.2 bar. The pressure and temperature at the start of compression are 1 bar and 16°C respectively. The compressed air is cooled at constant pressure to a temperature of 41°C, enters the expansion cylinder. Assuming both expansion and compression processes to be isentropic with $\gamma=1.4$, calculate:
 - i. Coefficient of performance **(5 marks)**
 - ii. Quantity of air in circulation per minute **(5 marks)**
 - iii. Piston displacement of compressor and expander **(5 marks)**
 - iv. Bore of compressor and expansion cylinders. The unit runs at 240 rpm and is double acting. Stroke length is 200mm. **(5 marks)**
 - v. Power required to drive the unit. **(5 marks)**
 - a. For air, take $\gamma=1.4$ and $c_p=1.003$ kJ/kg K.
2. Two 35 mm shafts are connected by a flanged coupling. The flanges are fitted with 6 bolts on 125 mm bolt circle. The shafts transmit a torque of 800 N-m at 350 rpm. Calculate,
 - a. diameter of bolts **(5 marks)**
 - b. thickness of flanges **(5 marks)**
 - c. key dimensions **(5 marks)**
 - d. hub length, and **(5 marks)**
 - e. power transmitted, **(5 marks)** for the following safe stresses:
 - Safe shear stress for shaft material = 63 MPa
 - Safe stress for bolt material = 56 MPa
 - Safe stress for cast iron coupling = 10 MPa
 - Safe stress for key material = 46 MPa

CASE II

[50 marks]

Discuss five most recent advances and innovations in the field of mechanical engineering that are shaping the future of industries and society.

- i. Explain what they are, their area of applications, how they would contribute to sustainability, efficiency and automation in modern engineering applications and their corresponding issues and challenges.
- ii. Elucidate on their feasibility of application in Bhutan and their issues and challenges.

TASHI DELEK