# MADE EASY

# GATE 2025

# Mechanical Engineering

## Questions & Solutions

**Exam held on**
**02/02/2025 (Forenoon Session)**

**GATE 2025**
**ME** Mechanical Engineering

**Detailed Solutions**
*Exam held on:*

Exam held on: **02-02-2025**
*Forenoon Session*

| SECTION - A | GENERAL APTITUDE |
|---|---|

**Q.1** Fish : Shoal :: Lion : _____
Select the correct option to complete the analogy.
(a) Pride
(b) School
(c) Forest
(d) Series

**Ans.** **(a)**

**Q.2** Identify the grammatically correct sentence:
(a) It is I who am responsible for this fiasco.
(b) It is myself who is responsible for this fiasco.
(c) It is I who is responsible for this fiasco.
(d) It is I who are responsible for this fiasco.

**Ans.** **(a)**

**Q.3** Two cars, P and Q, start from a point X in India at 10 AM. Car P travels North with a speed of 25 km/h and car Q travels East with a speed of 30 km/h. Car P travels continuously but car Q stops for some time after travelling for one hour. If both the cars are at the same distance from X at 11:30 AM, for how long (in minutes) did car Q stop?
(a) 10
(b) 12
(c) 15
(d) 18

**Ans.** **(c)**

**Q.4** The ceiling function of a real number $x$, denoted by $ce(x)$, is defined as the smallest integer that is greater than or equal to $x$. Similarly, the floor function, denoted by $fl(x)$, is defined as the largest integer that is smaller than or equal to $x$. Which one of the following statements is NOT correct for all possible values of $x$?
(a) $ce(x) \geq x$
(b) $fl(x) \leq x$
(c) $ce(x) \geq fl(x)$
(d) $fl(x) < ce(x)$

**Ans.** **(d)**

**Q.5** P and Q play chess frequently against each other. Of these matches, P has won 80% of the matches, drawn 15% of the matches and lost 5% of the matches.
If they play 3 more matches, what is the probability of P winning exactly 2 of these 3 matches?

(a) $\dfrac{48}{125}$

(b) $\dfrac{16}{125}$

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(c) $\dfrac{16}{25}$ (d) $\dfrac{16}{48}$

**Ans.** **(a)**

**Q.6** Identify the option that has the most appropriate sequence such that a coherent paragraph is formed:

P. At once, without thinking much, people rushed towards the city in hordes with the sole aim of grabbing as much gold as they could.

Q. However, little did they realize about the impending hardships they would have to face on their way to the city: miles of mud, unfriendly forests, hungry beasts and inimical local lords – all of which would reduce their chances of getting gold to almost zero.

R. All of them thought that easily they could lay their hands on gold and become wealthy overnight.

S. About a hundred years ago, the news that gold had been discovered in Kolar spread like wildfire and the whole State was in raptures.

(a) P $\rightarrow$ Q $\rightarrow$ R $\rightarrow$ S (b) Q $\rightarrow$ S $\rightarrow$ R $\rightarrow$ P

(c) S $\rightarrow$ Q $\rightarrow$ P $\rightarrow$ R (d) S $\rightarrow$ P $\rightarrow$ R $\rightarrow$ Q

**Ans.** **(d)**

**Q.7** If HIDE and CAGE are coded as 19-23-7-11 and 5-2-17-11 respectively, then what is the code for HIGH?

(a) 5-17-1-2 (b) 17-19-13-17

(c) 13-3-1-2 (d) 19-23-17-19

**Ans.** **(d)**

H I D E $\rightarrow$ 19   232   7   11
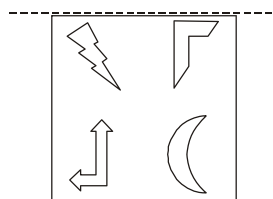
C A G E $\rightarrow$ 5   2    17   11

H I G H  $\rightarrow$ 19   23   17   19

**Q.8** The given figure is reflected about the horizontal dashed line and then rotated clockwise by 90° about an axis perpendicular to the plane of the figure.

Which one of the following options correctly shows the resultant figure?

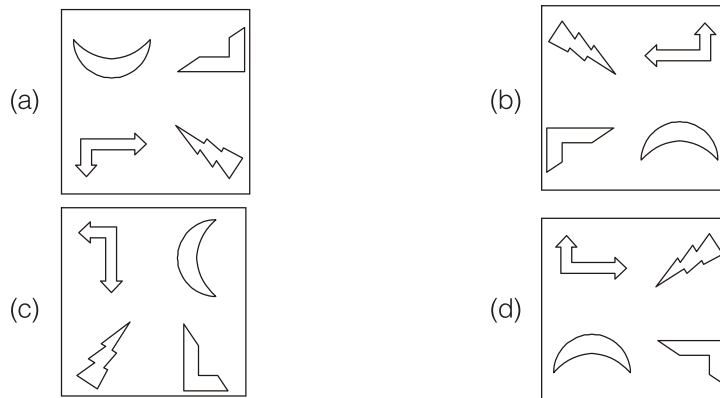Note: The figures shown are representative.

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(a)

(b)

(c)

(d)

**Ans.** **(b)**

*End of Solution*

**Q.9** Which one of the following options has the correct sequence of objects arranged in the increasing number of mirror lines (lines of symmetry)?
(a) Circle; Square; Equilateral triangle; Isosceles triangle
(b) Isosceles triangle; Equilateral triangle; Square; Circle
(c) Equilateral triangle; Isosceles triangle; Square; Circle
(d) Isosceles triangle; Square; Equilateral triangle; Circle

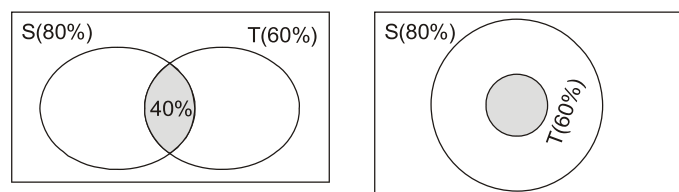**Ans.** **(b)**

*End of Solution*

**Q.10** A final year student appears for placement interview in two companies, S and T. Based on her interview performance, she estimates the probability of receiving job offers from companies S and T to be 0.8 and 0.6, respectively. Let $p$ be the probability that she receives job offers from both the companies. Select the most appropriate option.
(a) $0 \leq p \leq 0.2$             (b) $0.4 \leq p \leq 0.6$
(c) $0.4 \leq p \leq 0.4$          (d) $0.6 \leq p \leq 1.0$

**Ans.** **(b)**



*End of Solution*

■■■■

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**Q.11** Let A and B be real symmetric matrices of same size. Which one of the following options is correct?

(a)  $A^T = A^{-1}$  (b)  $AB = BA$

(c)  $(AB)^T = B^T A^T$  (d)  $A = A^{-1}$

**Ans.** **(c)**

A and B are symmetrix

$A^T = A,\ B^T = B$

**Q.12** For the differential equation given below, which one of the following options is correct?

$$\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0,\ 0 \le x \le 1,\ 0 \le y \le 1$$

(a)  $u = e^{x+y}$ is a solution for all $x$ and $y$

(b)  $u = e^x \sin y$ is a solution for all $x$ and $y$

(c)  $u = \sin x \sin y$ is a solution for all $x$ and $y$

(d)  $u = \cos x \cos y$ is a solution for all $x$ and $y$

**Ans.** **(b)**

$\nabla^2 U = 0 \Rightarrow$ Laplace equation

By option

$$u = e^x \sin y$$

$$\frac{d^2 U}{dx} = e^x \sin y$$

$$\frac{d^2 U}{dx^2} = e^x \sin y$$

$$\frac{d^2 U}{dx^2} + \frac{d^2 U}{dy^2} = e^x \sin y + e^x (-\sin y)$$

$$= 0$$

**Q.13** The divergence of the curl of a vector field is

(a)  the magnitude of this vector field

(b)  the argument of this vector field

(c)  the magnitude of the curl of this vector field

(d)  Zero

**Ans.** **(d)**

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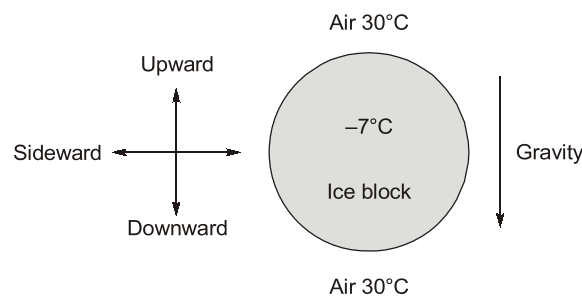**Q.14** If two unbiased coins are tossed, then what is the probability of having at least one head?

(a) 0.25 (b) 0.5

(c) 0.675 (d) 0.75

**Ans.** **(d)**

**Q.15** Let a spherical block of ice at –7°C be exposed to atmospheric air at 30°C with the gravitational direction as shown in the figure below. What will be the overall direction of air flow in this situation?



(a) Upward (b) Downward

(c) No motion (d) Sideward

**Ans.** **(b)**

Air close to the Ice Ball will go in downward direction becouse of weight is more than Buoyant force because $T_{iceball}$ is less.
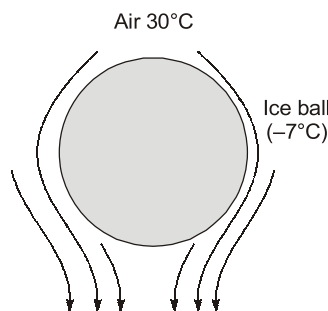
**Q.16** Consider two identical tanks with a bottom hole of diameter *d*. One tank is filled with water and the other tank is filled with engine oil. The height of the fluid column *h* is same in both the cases. The fluid exit velocity in the two tanks are $V_1$ and $V_2$. Neglecting all losses, which one of the following options is correct?

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Two identical tanks



(a) $V_2 > V_1$ 　　　　　　　　　　　　　(b) $V_2 = V_1$
(c) $V_2 < V_1$
(d) Insufficient data to definitively conclude the relationship between $V_1$ and $V_2$.

**Ans.** **(b)**

$$V_1 = V_2$$

As 　　　　　　Velocity $= \sqrt{2gh}$

*End of Solution*

**Q.17** In a laboratory experiment using a scaled down model to measure scour at a bridge pier, the Froude number is important. The ratio of the prototype length to the model length is 100. If the velocity of the model is 1 m s$^{-1}$, the velocity (in m s$^{-1}$) of the prototype is

(a) 0.1 　　　　　　　　　　　　　(b) 1
(c) 10 　　　　　　　　　　　　　(d) 100

**Ans.** **(c)**
We know that

$$\text{Froude number} = \frac{V}{\sqrt{L_g}}$$

According to question

$$\frac{V_m}{\sqrt{L_m g}} = \frac{V_P}{\sqrt{L_P g}}$$

$$\frac{1}{\sqrt{L_m}} = \frac{V_P}{\sqrt{L_P}}$$

$$\sqrt{\frac{L_P}{L_m}} = V_P$$

$$\sqrt{100} = V_P$$
$$V_P = 10 \text{ m/s}$$

*End of Solution*

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**Q.18** Air inside a rigid, thermally-insulated tank undergoes stirring as shown in the figure below. Which one of the following options is correct?

Stirrer

Air

Rigid, thermally-insulated tank
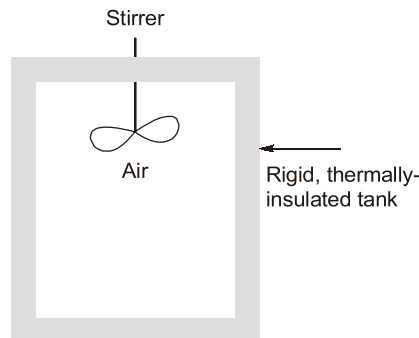
(a) The enthalpy of the air increases while the entropy of the air remains constant
(b) Both the enthalpy and the entropy of the air remain constant
(c) Both the enthalpy and the entropy of the air increase
(d) The enthalpy of the air decreases while the entropy of the air increases

**Ans. (c)**

**Q.19** In a psychrometric chart, one axis represents dry-bulb temperature. The axis, that is perpendicular to the dry-bulb temperature axis, represents
(a) wet-bulb temperature
(b) specific humidity
(c) relative humidity
(d) enthalpy

**Ans. (b)**

$\omega$ (kg/kg.d.a.)

$t$ (DBT)
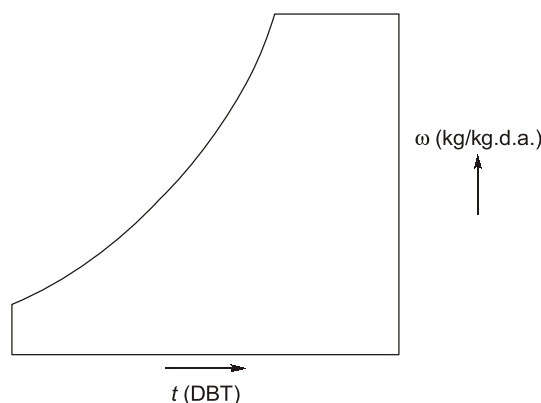
**Q.20** Among the following surface hardening processes, steel is heated to the lowest temperature in
(a) carburizing
(b) cyaniding
(c) nitriding
(d) carbonitriding

**Ans. (c)**

**Detailed Solutions**

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**Q.21** The welding process commonly used for fabricating tailor-welded blanks of dissimilar thickness for automotive applications is
(a) gas welding
(b) laser welding
(c) arc welding
(d) friction welding

**Ans.** **(b)**

*End of Solution*

**Q.22** The yield stress of a metal in uniaxial tension is 200 MPa. According to von Mises yield criterion, the yield stress (in MPa) of the metal in pure shear is closest to
(a) 115.5
(b) 100.0
(c) 66.7
(d) 141.4

**Ans.** **(a)**

$S_{yt}$ = 200 MPa.

$$S_{ys} = 0.577\ S_{yt} = 115.4\ \text{MPa}$$

*End of Solution*

**Q.23** In computer aided design (CAD), solid models can be constructed using
(a) boundary representation (B-rep)
(b) Bezier curves
(c) B-splines
(d) nonuniform rational B-splines (NURBS)

**Ans.** **(a)**

*End of Solution*

**Q.24** Ceramics and glass are machined by
(a) electric discharge machining
(b) ultrasonic machining
(c) electrochemical machining
(d) transferred arc plasma machining

**Ans.** **(b)**

*End of Solution*

**Q.25** When assembled, the hole $30^{+0.030}_{+0.000}$ mm and shaft $30^{+0.020}_{-0.020}$ mm will result in
(a) loose fit
(b) interference fit
(c) transition fit
(d) clearance fit

**Ans.** **(c)**

+0.030 mm

Maximum clearance 0.05 mm

Hole

Maximum interference 0.020 mm

+0.020 mm

Shaft

Basic size (zero line) 30 mm

– 0.020 mm

Type of fit = Transition

*End of Solution*

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**Q.26** A rigid circular disc of radius $r$ (in m) is rolling without slipping on a flat surface as shown in the figure below. The angular velocity of the disc is $\omega$ (in rad s$^{-1}$). The velocities (in m s$^{-1}$) at points O and A, respectively, are
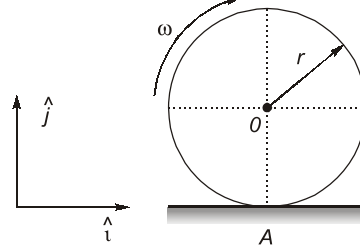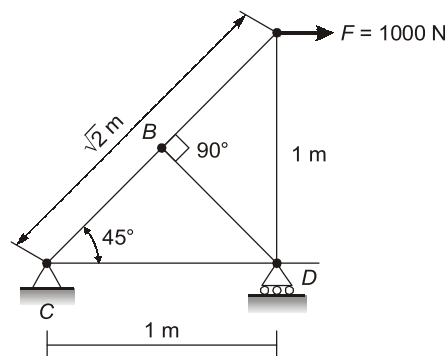
(a) $r\omega\hat{i}$ and $0\,\hat{i}$

(b) $-r\omega\,\hat{i}$ and $0\,\hat{i}$

(c) $-r\omega\,\hat{i}$ and $-r\omega\,\hat{i}$

(d) $r\omega\,\hat{i}$ and $r\omega\,\hat{i}$

**Ans.** **(a)**

*End of Solution*

**Q.27** A truss structure is loaded as shown in the figure below. Among the options given, which member in the truss is a zero-force member?

(a) BD

(b) BC

(c) BA

(d) AD

**Ans.** **(a)**

*End of Solution*

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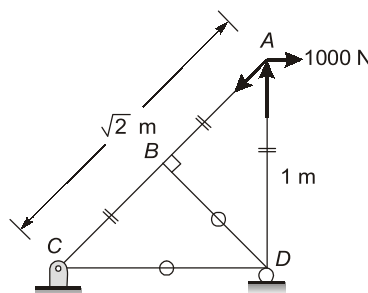
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**Q.28** A metallic square plate is subjected to a uniform hydrostatic pressure (P). Choose the correct Mohr's circle representing the state of stress at any point in the plate from the options given below.

For the Mohr's circle, normal stress is positive towards right and shear stress is positive in the upward direction.

(a) 

(b) 

(c) 

(d) 
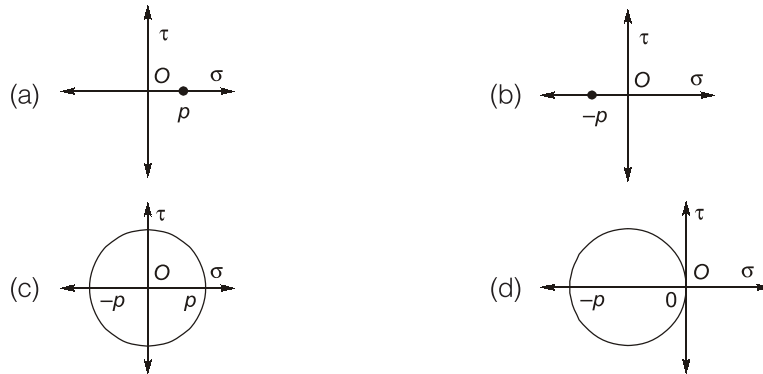
**Ans.** **(b)**

Due to hydrostatic pressure, Mohr's circle becomes a point on -ve axis.

*End of Solution*

**Q.29** In the context of balancing of rotating and reciprocating masses, which one of the following options is true?

(a) An unbalanced rigid rotor can be completely balanced using a single balancing mass

(b) An unbalanced rigid rotor can be completely balanced using two balancing masses attached in two distinct planes

(c) A single-cylinder internal combustion engine can be completely balanced using a single balancing mass

(d) A single-cylinder internal combustion engine can be completely balanced using two balancing masses

**Ans.** **(b)**

*End of Solution*

**Q.30** A shaft carries a helical spur gear. Which one of the following bearings can NOT be used to support it?

(a) Angular contact bearing        (b) Double-row ball bearing

(c) Straight roller bearing        (d) Tapered roller bearing

**Ans.** **(c)**

In helical gears, straight roller bearing can't be used because it is suitable for only radial loads.

*End of Solution*

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**Q.31** The values of a function $f$ obtained for different values of $x$ are shown in the table below.

| $x$ | 0 | 0.25 | 0.5 | 0.75 | 1.0 |
|-----|-----|------|-----|------|-----|
| $f(x)$ | 0.9 | 2.0 | 1.5 | 1.8 | 0.4 |

Using Simpson's one-third rule,

$\int_o^1 f(x)\,dx \approx$ _____ [Rounded off to 2 decimal places]

**Ans.** **(1.61 to 1.65)**

$$\int_0^1 f(x)\,dx = \frac{1}{3}\Big[(y_0 + y_x) + 4(y_1 + y_3 + y_5 + .....) + 2(y_2 + y_4 + y_6 .......)\Big]$$

$$= \frac{0.25}{3}\Big[(0.9 + 0.9) + 4(2 + 1.8) + 2(1.5)\Big]$$

$$= \frac{1}{4 \times 3}\Big[1.3 + 4 \times 3.8 + 3\Big] = \frac{19.5}{12} = 1.625$$
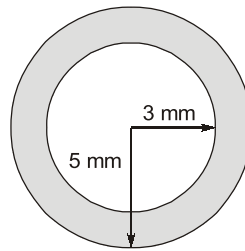
**End of Solution**

**Q.32** The thermal efficiency of an ideal air-standard Otto cycle is 0.5. The value of specific heat ratio of air is 1.4. The compression ratio of the cycle is_____ (rounded off to 1 decimal place).

**Ans.** **(5.5 to 5.9)**

Given,
$$\eta_0 = 1 - \frac{1}{r^{\gamma - 1}}$$

$$0.5 = 1 - \frac{1}{(r)^{1.4 - 1}}$$

$$\frac{1}{r^{0.4}} = 1 - 0.5$$

$$r^{0.4} = \frac{1}{0.5} = 2$$

$$r = (2)^{1/0.4}$$
$$r = 2^{2.5}$$
$$r = 5.6568$$

**End of Solution**

**Q.33** During a welding operation, thermal power of 2500 W is incident normally on a metallic surface. As shown in the figure below (figure is NOT to scale), the heated area is circular. Out of the incident power, 85% of the power is absorbed within a circle of radius 5 mm while 65% is absorbed within an inner concentric circle of radius 3 mm. The power density in the shaded area is _____ Wmm$^{-2}$ (rounded off to 2 decimal places).

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**Ans.** **(9.92 to 9.98)**

Total incident heat is = 2500 W

5 m palte absorption = 85%

5 m plate sbrosption = 65%

Absorption by shaded area = (85 − 65)% = 20%

$$q_{absorbed\,(shaded)} = 2500 \times 0.20 = 500 \text{ W}$$

$$\text{Heat density} = \frac{500}{A_{shaded}} = \frac{500}{\pi \left(5^2 - 3^2\right)} = 9.947 \text{ W/mm}^2$$

*End of Solution*

**Q.34** A liquid metal is poured in a mold cavity of size 200 mm × 200 mm × 200 mm. The cooling is uniform in all directions with NO additional compensation for shrinkage. Considering the volumetric shrinkage during solidification and solid contraction as 7% and 8%, respectively, the length of the cube edge after cooling down to the room temperature is _____ mm (rounded off to 1 decimal place).
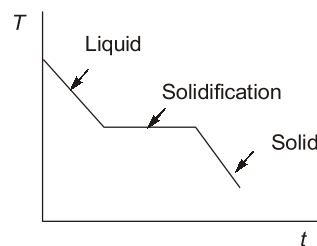
**Ans.** **(189.8 to 190)**

Volumetric solidification contraction = 7%

Volumetric solid contraction = 8%
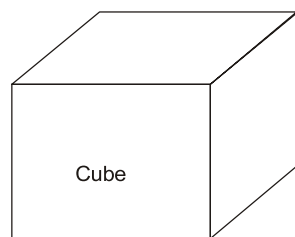


Volume of casting = (Volume of liquid metal) (1 − Shrinkage)

$$= (200)^3 \times 0.93 \times 0.92$$

$$a^3 = 68,44,800 \text{ mm}^3$$

$$a = 189.868 \text{ mm}$$

*End of Solution*

**Q.35** A block of mass 1 kg connected to a spring of stiffness 10 N m$^{-1}$ is operating in a viscous medium such that the damping ratio (or damping factor) is equal to the ratio of the damped frequency to the natural frequency. The magnitude of the damping ratio for this system is _____ (rounded off to 2 decimal places).

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**Ans.** (0.7 to 0.72)

$$\frac{\omega_d}{\omega_n} = \xi \text{ (given)}$$

$$\left(\sqrt{1-\xi^2}\right)\omega_n = \omega_d$$

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

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

$$2\xi^2 = 1$$

$$\xi^2 = \frac{1}{2} = 0.5$$

$$\xi = 0.707$$
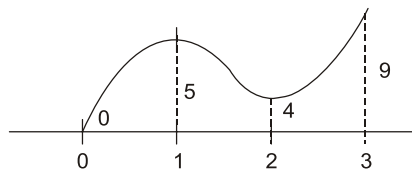
**Q.36** In the closed interval [0,3], the minimum value of the function $f$ given below is
$$f(x) = 2x^3 - 9x^2 + 12x$$
(a) 0                             (b) 4
(c) 5                             (d) 9

**Ans.** (a)

$$f(x) = 2x^3 - 9x^2 + 12x$$
$$f'(x) = 6x^3 - 18x + 12 = 6(x^2 - 3x + 2) = 0$$
$$= 6(x - 1)(x - 2) = 0$$
$$x = 1, x = 2; \quad f''(x) = 12x - 18$$
$$f''(x)\big|_{x=1} = 12 \times 1 - 18 = -6 < 0$$

$x = 1$ maxima point,

$$f''(x)\big|_{x=2} = 12x - 18 = 6 > 0$$

$x = 2$ minima,      $f(x) = 2x^3 - 9x^2 + 12x$

$$f(x)\big|_{x=0} = 0$$

$$f(x)\big|_{x=1} = 2(D^3 - 9(1)^2 + 12 \times 1 = 2 - 9 + 12) = 5$$

$$f(x)\big|_{x=2} = 2(2)^3 - 9(2)^2 + 12 \times 2 = 4$$

$$f(x)\big|_{x=3} = 2(3)^3 - 9(3)^2 + 12 \times 3 = 9$$



So, minimum value = 0

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# ESE 2025
## Prelims

### Offline Test Series
**Commencing from**
**9TH March, 2025**

# MADE EASY

## Total 22 Tests

### Paper-I : 11 Tests
**GS & Engineering Aptitude**
--------------------------------------

- 8 Multiple Subject Tests
  of 50 Questions (**400 Ques**)
  *Time : 60 minutes*

  ➕

- 2 Full Syllabus Tests
  of 100 Questions (**300 Ques**)
  *Time : 120 minutes*

  ➕

- **+ 1 Anubhav Test**
  Full Syllabus

### Paper-II : 11 Tests
**Engineering Discipline**
--------------------------------------

- 8 Multiple Subject Tests
  of 75 Questions (**600 Ques**)
  *Time : 90 minutes*

  ➕

- 2 Full Syllabus Tests
  of 150 Questions (**450 Ques**)
  *Time : 180 minutes*

  ➕

- **+ 1 Anubhav Test**
  Full Syllabus

**Each question carries 2 marks**  •  **Negative marking = 2/3 marks**

**Latest Pattern**
Tests are designed as per latest syllabus, trend and pattern of ESE. Paper-I (GS and Engineering aptitude) and Paper-II (Technical) both are covered.

**Care for Accuracy**
All care has been taken to ensure the highest level of accuracy.

**Cyclic Revision**
Dynamic test series for cyclic revision of subjects. Tests are time tabled with "New Topics" and "Repeat Topics" to maintain the continuity and a perfect balance between tech and non tech subjects.

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Quality Questions framed by experienced research and development team of MADE EASY.

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# GATE 2025
## ME | Mechanical Engineering

**Detailed Solutions**
*Exam held on:*

Exam held on: **02-02-2025**

*Forenoon Session*

**Q.37** Considering the actual demand and the forecast for a product given in the table below, the mean forecast error and the mean absolute deviation, respectively, are

| Period | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Actual demand | 425 | 415 | 420 | 430 | 427 | 418 | 422 | 416 | 426 | 421 |
| Forecast | 427 | 422 | 416 | 422 | 423 | 420 | 419 | 418 | 430 | 415 |

(a)  0.8 and 42.0
(b)  0.8 and 4.2
(c)  8.0 and 42.0
(d)  8.0 and 4.2

**Ans.** **(b)**

| Period | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Demand | 425 | 415 | 420 | 430 | 427 | 418 | 422 | 416 | 426 | 421 |
| Forecast | 427 | 422 | 416 | 422 | 423 | 420 | 419 | 418 | 430 | 415 |
| $e_i$ | –2 | –7 | 4 | 8 | 4 | –2 | 3 | –2 | –4 | 6 |

$$e_i = D_i - F_i$$

$$\sum |e_i| = 42$$

$$MAD = \frac{\sum |e_i|}{n} = \frac{42}{10} = 4.2 \qquad [\text{where } n \text{ is number of period}]$$

$$\text{Mean forecast error (MFE)} = \frac{\sum (e_i)}{n} = \frac{8}{10} = 0.8$$

*End of Solution*

**Q.38** Match the mold elements in the casting process with the most suitable function

**Column 1**
P.  Blind riser
Q.  Chill
R.  Skim bob
S.  Core
T.  Insulating sleeve
U.  Inoculant

**Column 2**
I.  Casting with internal cavity
II.  Molten metal reservoir
III.  Nucleating agent
IV.  Assisting in faster heat removal from melt
V.  Removal of impurities
VI.  Increasing the solidification time

(a)  P-II, Q-IV, R-V, S-I, T-VI, U-III
(b)  P-II, Q-V, R-VI, S-I, T-III, U-IV
(c)  P-V, Q-I, R-VI, S-III, T-II, U-IV
(d)  P-II, Q-IV, R-I, S-V, T-VI, U-III

**Ans.** **(a)**

*End of Solution*

**Q.39** Wire drawing operation is performed on a perfectly plastic metal without any strain hardening. Assuming no friction and no redundant work, the maximum possible percentage reduction in area in a single pass is closest to

(a)  51.2
(b)  63.2
(c)  75.0
(d)  93.2

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Detailed Solutions
Exam held on:
Exam held on: 02-02-2025
Forenoon Session

GATE 2025
ME Mechanical Engineering

Ans. (b)

$$\sigma_d = \sigma_o \ln\frac{A_0}{A_f}$$

For maximum possible reduction, $\sigma_d = \sigma_o$

$$\therefore \qquad \frac{A_0}{A_f} = e$$

$$\frac{A_0 - A_f}{A_0} = 1 - \frac{1}{e} = 0.632 \text{ or } 63.2\%$$

*End of Solution*

Q.40 In relation to additive manufacturing, match the following

| Process | | Layer creation technique | | Material | |
|---|---|---|---|---|---|
| **P.** | Stereolithography | **1.** | Injection of powder stream | **I.** | Paper |
| **Q.** | Fused deposition modeling | **2.** | Extrusion of melted polymer | **II.** | Epoxy |
| **R.** | Laminated object manufacturing | **3.** | Liquid layer curing | **III.** | Titanium |
| **S.** | Laser-engineered net shaping | **4.** | Sheet material deposition | **IV.** | Acrylonitrile butadiene styrene (ABS) |

(a)  P-3-III, Q-1-IV, R-4-I, S-2-II
(b)  P-3-II, Q-2-IV, R-4-I, S-1-III
(c)  P-4-III, Q-2-IV, R-1-II, S-3-I
(d)  P-3-II, Q-2-IV, R-1-I, S-4-III

Ans. (b)

*End of Solution*

Q.41 A plate of 30 mm thickness is fed through a rolling mill with two powered rolls. Each roll has a diameter of 500 mm. The plate thickness is to be reduced to 27 mm in a single pass. Assume no change in width. The process feasibility and the maximum draft (in mm) can be represented, respectively, as
Use the coefficient of friction as 0.12
(a)  feasible and 3.6
(b)  NOT feasible and 2.6
(c)  feasible and 3.0
(d)  NOT feasible and 6.0

Ans. (a)

$$\Delta h_{max} = \mu^2 R$$

$$= (0.12)^2 \times \frac{500}{2} = 3.6 \text{ mm}$$

Maximum possible reduction in single pass.
According to Question,

$$\Delta h = h_i - h_f$$
$$= 30 - 27 = 3 \text{ mm}$$

So feasible.

*End of Solution*

GATE 2025 ME Mechanical Engineering

**Detailed Solutions**
*Exam held on:*
Exam held on: **02-02-2025**
*Forenoon Session*

**Q.42** The system shown in the figure below consists of a cantilever beam (with flexural rigidity EI and negligible mass), a spring (with spring constant $K$ and negligible mass) and a block of mass $m$. Assuming a lumped parameter model for the system, the fundamental natural frequency ($\omega_n$) of the system is
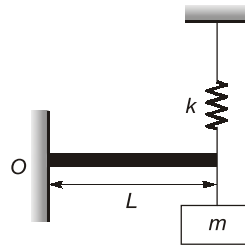
(a) $\sqrt{\dfrac{\dfrac{3EI}{L^3} + K}{m}}$

(b) $\sqrt{\dfrac{\dfrac{EI}{L^3} + K}{m}}$

(c) $\sqrt{\dfrac{\dfrac{3EI}{L^3} + K}{2m}}$

(d) $\sqrt{\dfrac{\dfrac{EI}{L^3} + K}{2m}}$

**Ans.** **(a)**
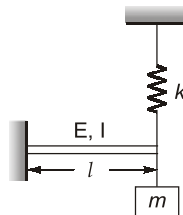
First we are going to calculate bending stiffness of beam ($K_{\text{beam}}$)

Static deflection ($\Delta$) = $\dfrac{Wl^3}{3EI} = \dfrac{mgl^3}{3EI}$

$\sqrt{\dfrac{K_{beam}}{m}} = \sqrt{\dfrac{g}{\Delta}}$

$\dfrac{K_{beam}}{m} = \dfrac{g}{\dfrac{mgl^3}{3EI}}$

$K_{\text{beam}} = \dfrac{3EI}{l^3}$

Equivalent stiffness, $K_{eq} = K_{\text{beam}} + K$

$= \left( \dfrac{3EI}{l^3} + K \right)$

$\omega_n = \sqrt{\dfrac{K_{eq}}{m}} = \sqrt{\dfrac{\dfrac{3EI}{l^3} + K}{m}}$

*End of Solution*

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GATE 2025
ME | Mechanical Engineering

**Detailed Solutions**
*Exam held on:*

Exam held on: **02-02-2025**

*Forenoon Session*

**Q.43** The endurance limit of a specific grade of steel is same as its yield strength. The ultimate strength of this grade of steel is twice of its yield strength. A component made of this steel is loaded in tension and unloaded periodically. It is required that the component does NOT fail for at least $10^6$ loading cycles, as per the Soderberg law. Considering a factor of safety of 2, the maximum applied tensile principal stress is

(a) one-fourth of the endurance limit    (b) half of the endurance limit

(c) the endurance limit                         (d) twice the endurance limit

**Ans.** **(b)**

For repeated fatigue stress condition, $\sigma_{max}$ using soderberg equation,

if $\sigma_e = S_{yt}$; $S_{ut} = 2S_{yt}$ ; $N = 2$

For repeated fatiue stress condition,

$$\sigma_m = \sigma_a = \frac{\sigma_{max}}{2}$$

$$\frac{\sigma_m}{\sigma_{yt}} + \frac{\sigma_a}{\sigma_e} = \frac{1}{N}$$

$$\frac{\sigma_{max}}{2\sigma_e} + \frac{\sigma_{max}}{2\sigma_e} = \frac{1}{2}$$

$$\frac{\sigma_{max}}{2\sigma_e} + \frac{\sigma_{max}}{2\sigma_e} = \frac{1}{2}$$

$$\sigma_{max} = \frac{\sigma_e}{2}$$

*End of Solution*

**Q.44** For a fully-developed pipe flow, which of the following options is/are correct?

(a) For the same maximum velocity, the average velocity is higher in the turbulent regime than that of the laminar regime

(b) Compressibility effects are important if Mach number is less than 0.3

(c) For laminar flow, the friction factor is independent of surface roughness

(d) For laminar flow, friction factor decreases with decrease in Reynolds number

**Ans.** **(a, c)**

(a) For same maximum velocity average velocity of turbulent flow is larger than that of laminar flow because the velocity variation is parabolic in laminar regime while logarithmic in turbulent regime.

(c) Friction factor is independent of surface roughness in laminar flow.

*End of Solution*

**Q.45** If *C* is the unit circle in the complex plane with its center at the origin, then the value of *n* in the equation given below is _____ (rounded off to 1 decimal place).

$$\oint_c \frac{Z^3}{\left(Z^2 + 4\right)\left(Z^2 - 4\right)} dz = 2\pi in$$

**GATE 2025**

**ME** | Mechanical Engineering

**Detailed Solutions**
*Exam held on:*

Exam held on: **02-02-2025**

*Forenoon Session*

**Ans.** (–0.1 to 0.1)

Poles: $(z^2 - 4)(z^2 + 4) = 0$

$$z = \pm 2, \pm 2i$$

All the poles are lies outstack the closed curve.

**Q.46** The directional derivative of the function *f* given below at the point (1, 0) in the direction of $\frac{1}{2}\left(\hat{i} + \sqrt{3}\hat{j}\right)$ is_____ (Rounded off to 1 decimal place).

$$f(x, y) = x^2 + xy^2$$

**Ans.** (0.9 to 1.1)

$$f(x, y) = x^2 + xy^2$$

Let

$$\vec{a} = \frac{1}{2} + \frac{\sqrt{3}}{2}\hat{j}$$

$$\nabla f = \frac{\partial f}{\partial x}\hat{i} + \frac{\partial f}{\partial y}\hat{j} = \left(2x + y^2\right)\hat{i} + \left(2xy\right)\hat{j}$$

$$\nabla f\Big|_{(1,0)} = \left(2 \times 1 + 0\right)\hat{i} + 0\hat{j} = 2\hat{i}$$

$$\text{D.D.} = \nabla f \cdot \frac{\vec{a}}{|a|} = \left(2x\hat{i}\right) \cdot \frac{\left(\frac{\hat{i}}{2} + \frac{\sqrt{3}}{2}\hat{j}\right)}{\sqrt{\frac{1}{4} + \frac{3}{4}}}$$

$$= \frac{2 \times \frac{1}{2}}{1} = 1$$

**Q.47** Let *y* be the solution of the differential equation with the initial conditions given below. If *y* (*x* = 2) = *A* ln2, then the value of *A* is _____ (rounded off to 2 decimal places).

$$x^2\frac{d^2y}{dx^2} + 3x\frac{dy}{dx} + y = 0 \quad y(x = 1) = 0 \quad 3x\frac{dy}{dx}(x = 1) = 1$$

**Ans.** (0.45 to 0.55)

$$\frac{x^2 d^2 y}{dx^2} + 3x\frac{dy}{dx} + y = 0$$

$$(D(D - 1) + 3D + 1)y = 0$$

$$(D^2 - D + 3D + 1)y = 0$$

$$(D^2 + 2D + 1)y = 0$$

$$(D^2 + 1) = 0$$

AE: $\quad (m + 1)^2 = 0$

$$m = -1, 1$$

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### Live-Online Batches

| | |
|---|---|
| CE/ME/EE/E&T | 17th Mar (Evening) |
| CE (L8) | 18th Mar (Morning) |
| EC/IN/CS | 17th Mar (Evening) |

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- CE, ME, EE : 750 to 800 Hrs.
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- CE, ME, EE, EC : 1050-1100 Hrs.

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**Note :** Courses with SES (State Engineering Services) are also available.

**Low Cost EMI Facility Available**   **Admissions Open**

GATE 2025

ME Mechanical Engineering

Detailed Solutions

Exam held on:

Exam held on: **02-02-2025**

*Forenoon Session*

$$y = (C_1 + C_2 t)e^{-t}$$

$$y = (C_1 + C_2 \ln x)e^{-\ln x}$$

$$y = (C_1 + C_2 \ln x)e^{\ln\left(\frac{1}{x}\right)}$$

$$y = (C_1 + C_2 \ln x)\frac{1}{x}$$

At $n = 1$, $y = 0$

$$0 = (C_1 + C_2 \ln 1)\frac{1}{1}$$

$$0 = C_1 + 0$$

$$C_1 = 0$$

$$y = \frac{C_1}{x} + \frac{C_2 \ln}{x}$$

$$\frac{dy}{dx} = -\frac{C_1}{x^2} + C_2 \frac{x\left(\frac{1}{x}\right) - \ln x}{x^2} = \frac{-C_1 + C_2(1 - \ln x)}{x^2}$$

At $x = 1$, $\dfrac{dy}{dx} = 1$

$$1 = 0 + \frac{C_2 + (1 - \ln 1)}{1} = C_2$$

Now,

$$y = \frac{C_1}{x} + \frac{C_2 \ln x}{x}$$

$$y = \frac{\ln x}{x}$$

At $x = 2$, $y = A \ln 2$

$$A \ln 2 = \frac{\ln 2}{2}$$

$$A = \frac{1}{2}$$

*End of Solution*

**Q.48** Consider a cylindrical furnace of 5 m diameter and 5 m length with bottom, top and curved surfaces maintained at uniform temperatures of 800 K, 1500 K and 500 K, respectively. The view factor between the bottom and top surfaces, $F_{12}$ is 0.2. The magnitude of net radiation heat transfer rate between the bottom surface and the curved surface is _____ kW (rounded off to 1 decimal place).

All surfaces of the furnace can be assumed as black.

The Stefan-Boltzmann constant, $\sigma = 5.67 \times 10^{-8}$ W m$^{-2}$ K$^{-4}$.

$T_2$ = 1500 K

Top (2)

Curved (3)

$T_3$ = 500 K

Bottom (1)

$T_1$ = 1500 K

**Detailed Solutions**

*Exam held on:*

GATE 2025
**ME** | **Mechanical Engineering**

Exam held on: **02-02-2025**

*Forenoon Session*
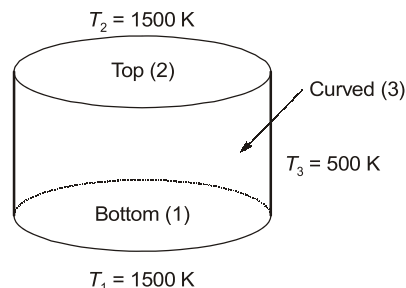
**Ans.** (308 to 310)

$D = H = 5$ m, $F_{13} = 0.8$, $F_{23} = 0.8$, $F_{13} + F_{11} + F_{12} = 1$
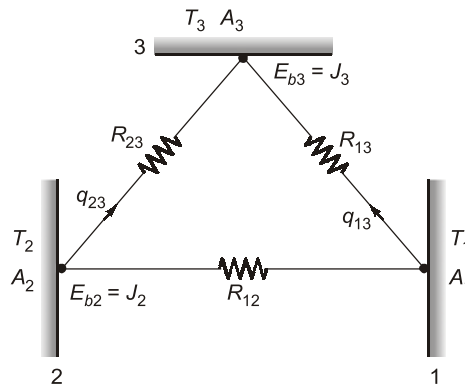
$$F_{12} = 1 - F_{13} = 1 - 0.8 = 0.2$$

$$A_1 = A_2 = \frac{\pi}{4}D^2$$

$$A_3 = \pi DH$$

$$R_{12} = \frac{1}{A_1 F_{12}} = \frac{1}{\frac{\pi D^2}{4} \times 0.2} = \frac{20}{\pi D^2}$$

$$R_{23} = \frac{1}{A_2 F_{23}} = \frac{1}{\frac{\pi D^2}{4} \times 0.8} = \frac{5}{\pi D^2}$$

$$R_{13} = \frac{1}{A_1 F_{13}} = \frac{1}{\frac{\pi D^2}{4} \times 0.8} = \frac{5}{\pi D^2}$$



$$q_{23} = \frac{E_{b2} - E_{b3}}{R_{23}} = \frac{\sigma\left(T_2^4 - T_3^4\right)}{\dfrac{5}{\pi D^2}}$$

$$= 5.67 \times 10^{-8}\left(1500^4 - 500^4\right) \times \frac{\pi(5)^2}{5}$$
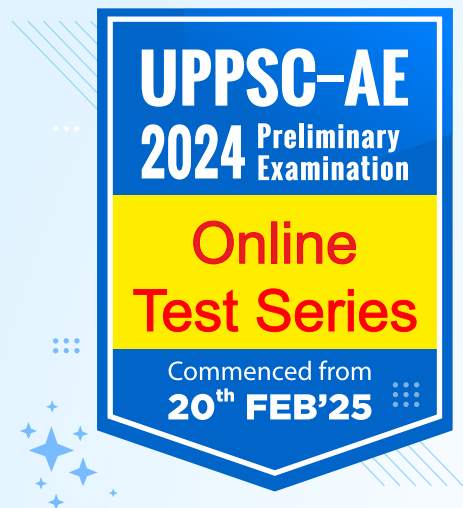
$$= 4453207.586 \text{ W}$$

$$= 4453.207 \text{ kW}$$

$$q_{13} = \frac{E_{b1} - E_{b3}}{R_{13}} = \frac{\sigma\left(T_1^4 - T_3^4\right)}{R_{13}} = \frac{5.67 \times 10^{-8}\left(800^4 - 500^4\right)}{\dfrac{5}{\pi D^2}}$$

$$= \frac{5.67 \times 10^{-8} \times \pi(5)^2\left(800^4 - 500^4\right)}{5}$$

$$q_{13} = 309141.6707 \text{ W} = 309.141 \text{ kW}$$

*End of Solution*

# MADE EASY

## UPPSC-AE 2024 Preliminary Examination
### Online Test Series
Commenced from **20th FEB'25**

## Total 10 Tests (Total 1125 Questions)
### 5 Part Syllabus Tests + 5 Full Syllabus Tests

**Paper Pattern:**
- Each question carries 2 Marks
- There is a penalty of 0.66 Mark for every wrong answer.

**Test Series Features:**
- Quality questions as per UPPSC-AE standard and pattern.
- Step by step detailed solutions for tough questions.
- Detailed performance analysis report.

**Stream : CE, ME, EE**

## Test Series Schedule

| Test No. | Activate Date | Total Questions | Total Time | Test Type | Syllabus Covered |
|---|---|---|---|---|---|
| 1 | 20th Feb 2025 | 75 Qs | 1 Hour | Part Syllabus Test | General Principles of Design and Drawing, Industrial Safety and Safety Standards, Engineering Materials, Quality Control, Types of Machinery and Maintenance, Production and Construction, Handling and Storage of Products |
| 2 | 27th Feb 2025 | 75 Qs | 1 Hour | Part Syllabus Test | Basics of project Management, Information and communication technologies, Ethics and values in engineering profession, intellectual property rights, Role of science and technology in daily life, recent developments in applied sciences, basics of artificial intelligence and robotics |
| 3 | 6th Mar 2025 | 75 Qs | 1 Hour | Part Syllabus Test | Green Energy, Energy conversion principles, Climate change, Disaster Management, Basics of thermodynamics, Water resources and conservation processes, Basics of measurement and instrumentation, Human health and sanitation |
| 4 | 13th Mar 2025 | 75 Qs | 1 Hour | Part Syllabus Test | General Hindi |
| 5 | 20th Mar 2025 | 75 Qs | 1 Hour | Part Syllabus Test | Indian History, Indian Polity, Geography, GK & Miscellaneous and Current Affairs |
| 6 | 27th Mar 2025 | 150 Qs | 2 Hours | Full Syllabus Test | Full Syllabus Test (100 Qs. Engineering Aptitude + 25 Hindi + 25 General Studies) |
| 7 | 3rd Apr 2025 | 150 Qs | 2 Hours | Full Syllabus Test | Full Syllabus Test (100 Qs. Engineering Aptitude + 25 Hindi + 25 General Studies) |
| 8 | 5th Apr 2025 | 150 Qs | 2 Hours | Full Syllabus Test | Full Syllabus Test (100 Qs. Engineering Aptitude + 25 Hindi + 25 General Studies) |
| 9 | 8th Apr 2025 | 150 Qs | 2 Hours | Full Syllabus Test | Full Syllabus Test (100 Qs. Engineering Aptitude + 25 Hindi + 25 General Studies) |
| 10 | 11th Apr 2025 | 150 Qs | 2 Hours | Full Syllabus Test | Full Syllabus Test (100 Qs. Engineering Aptitude + 25 Hindi + 25 General Studies) |

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Detailed Solutions

Exam held on:

**GATE 2025**

**ME** Mechanical Engineering

Exam held on: **02-02-2025**

*Forenoon Session*

**Q.49** A pitot tube connected to a U-tube mercury manometer measures the speed of air flowing in the wind tunnel as shown in the figure below. The density of air is 1.23 kg m$^{-3}$ while the density of water is 1000 kg m$^{-3}$. For the manometer reading of $h$ = 30 mm of mercury, the speed of air in the wind tunnel is_____ m s$^{-1}$ (rounded off to 1 decimal place).

Assume: Specific gravity of mercury = 13.6

Acceleration due to gravity = 10 m s$^{-2}$
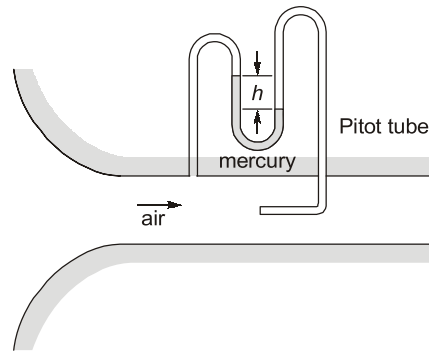


**Ans.** **(80 to 83)**

Pitot tube

We kowon that, $V = \sqrt{2gh}$

$$h = x\left[\frac{\rho_m}{\rho_f} - 1\right]$$

$$h = \frac{30}{1000}\left[\frac{13600}{1.23} - 1\right] = 331.67 \text{ m}$$

$$V = \sqrt{2 \times 10 \times 331.67}$$

$$V = 81.45 \text{ m/s}$$

*End of Solution*

**Q.50** Consider a velocity field $\vec{V} = 3z\hat{i} + 0\hat{j} + Cx\hat{k}$, where C is a constant. if the flow is irrotational, the value of C is _____ (rounded off to 1 decimal place).

**Ans.** **(2.9 to 3.1)**

For irrotational flow, $\nabla \times \vec{V} = 0$

$$\omega_{xz} = \frac{1}{2}\left(\frac{\partial w}{\partial x} - \frac{\partial u}{\partial z}\right) = 0$$

$$\frac{1}{2}(c - 3) = 0$$

$$c = 3$$

*End of Solution*

Detailed Solutions

*Exam held on:*

GATE 2025
ME Mechanical Engineering

Exam held on: **02-02-2025**

*Forenoon Session*

**Q.51** Water enters a tube of diameter, $D = 60$ mm with mass flow rate of 0.01 kg s$^{-1}$ as shown in the figure below. The inlet mean temperature is $T_{m,i} = 293$ K and the uniform heat flux at the surface of the tube is 2000 Wm$^{-2}$. For the exit mean temperature of $T_{m,o} = 353$ K, the length of the tube, $L$ is _____m (rounded off to 1 decimal place). Use the specific heat of water as 4181 J kg$^{-1}$ K$^{-1}$.
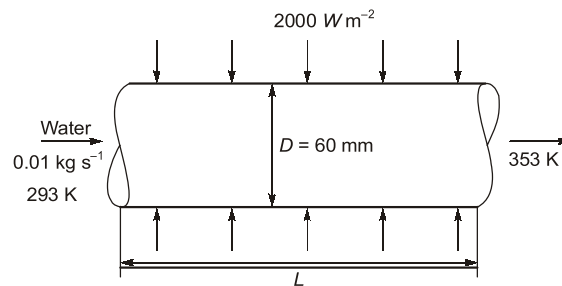


**Ans.** **(6.5 to 6.8)**

Given: D = 60 mm = 0.060 meter, $T_{bm(inlet)} = 293$ K, $T_{bm\ (outlet)} = 353$ K, $q'' = 2000$ W/m$^2$, $\dot{m} = 0.01$ kg/s, $C_p = 4180$
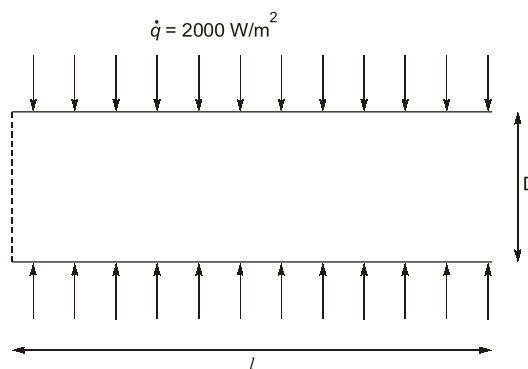


Total rate of heat transfe:

$$q = q''(\pi DL) = \dot{m}C_p\left(T_{bm(outlet)} - T_{bm(inlet)}\right)$$

$$2000 \times \pi \times 0.060 \times l = 0.01 \times 4180 \times (353 - 293)$$
$$\Rightarrow \qquad\qquad\qquad l = 6.6526 \text{ meter}$$
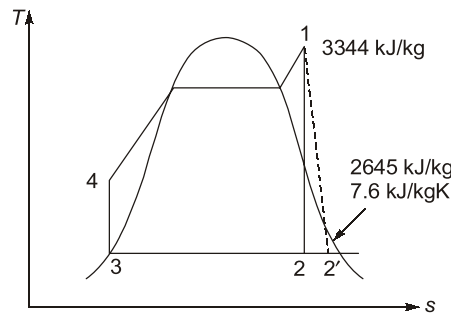
*End of Solution*

**Q.52** A thermal power plant is running with no reheat or regeneration. The specific enthalpy and specific entropy of steam at the turbine inlet are 3344 kJ kg$^{-1}$ and 6.5 kJ kg$^{-1}$ K$^{-1}$, respectively. The turbine isentropic efficiency is 0.9, and the mass flow rate of steam at the turbine inlet is 102 kg s$^{-1}$. The turbine power output is___MW (rounded off to 1 decimal place). Properties of saturated liquid and saturated vapor at turbine exit pressure

| Saturated liquid water | | Saturated liquid vapor | |
|---|---|---|---|
| Specific entropy (kJ kg$^{-1}$) | Specific entropy (kJ kg$^{-1}$/K$^{-1}$) | Specific enthalpy (kJ kg$^{-1}$) | Specific entroopy (kJ kg$^{-1}$K$^{-1}$) |
| 341 | 1.1 | 2645 | 7.6 |

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**Ans.** (98.5 to 101.5)



$\eta_T = 0.9, \ \dot{m} = 102 \ \text{kg/sec}$

$$S_1 = S_2$$
$$6.5 = 101 + x(7.6 - 1.1)$$
$$x = 0.83076$$
$$h_2 = 341 + 0.83076 \, (2645 - 341)$$
$$= 2255.092$$
$$W_T = (h_1 - h_2)\eta_T = (3344 - 2255.092) \times 9$$
$$= 980.016 \ \text{kJ/kg}$$
$$P = \dot{m} \times W_T = 102 \times 980.016$$
$$= 99961.726 \ \text{K} = 99.961 \ \text{MW}$$

*End of Solution*

**Q.53** Consider a Pelton wheel of 1 m diameter. The magnitude of relative velocity of water at the bucket inlet is same as the magnitude of relative velocity of water at the bucket exit. The absolute speed of water at the bucket inlet is 125.66 m s-1. For maximum power output from the Pelton wheel, the rpm of the Pelton wheel is___(rounded off to 1 decimal place).

**Ans.** (1197 to 1203)

We know that for maximum power condition,

$$u = \frac{V_1}{2} = 62.83 \ \text{m/s}$$

$$u = u_1 = u_2 = 62.83 = \frac{\pi DN}{60} = \frac{\pi \times 1 \times N}{60}$$

$$N = 1199.97 \simeq 1200 \ \text{rpm}$$

*End of Solution*

**Q.54** A thermodynamically closed system contains 1 kg of hydrogen. The system undergoes a reversible polytropic process with polytropic index 1.3. The work output during the process is 400 kJ. During the process, hydrogen behaves as an ideal gas with constant specific heats. The absolute value of heat transfer during the process is _____ kJ (rounded off to 1 decimal place).

Specific heat of hydrogen at constant pressure = 14.56 kJ kg$^{-1}$ K$^{-1}$

Specific heat of hydrogen at constant volume = 10.4 kJ kg$^{-1}$ K$^{-1}$

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**Ans.** **(99 to 101)**

$$Q_{Poly} = W_{Poly} \times \frac{\gamma - n}{\gamma - 1} \qquad (\because \gamma = 1.4)$$

$$= 400 \times \frac{1.4 - 1.3}{1.4 - 1} = 100 \text{ kJ}$$

*End of Solution*

**Q.55** A heat pump, operating in reversed Carnot cycle, maintains a steady air temperature of 300 K inside an auditorium. The heat pump receives heat from the ambient air. The ambient air temperature is 280 K. Heat loss from the auditorium is 15 kW. The power consumption of the heat pump is____ kW (rounded off to 2 decimal places).
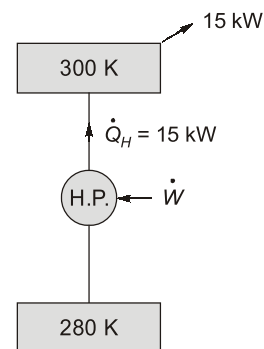
**Ans.** **(0.95 to 1.1)**

$$COP_{HP} = \frac{T_H}{T_H - T_L}$$

$$\frac{\dot{Q}_H}{\dot{W}} = \frac{300}{300 - 280}$$
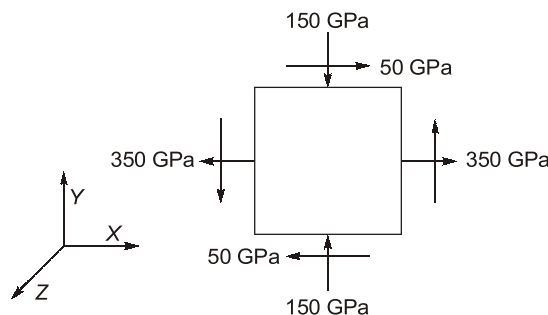
$$\frac{15}{\dot{W}} = 15$$

$$\dot{W} = 1 \text{ kW}$$



*End of Solution*

**Q.56** The state of stress at a point is shown in the figure given below. Under plane stress assumption, the normal strain along the thickness direction ($\varepsilon_{zz}$) is____(rounded off to 2 decimal places).
Use the Young's Modulus $E$ = 200 GPa and Poisson's ratio $\nu$ = 0.27.



**Ans.** **(−0.29 to −0.25)**

Given: $\varepsilon_{zz}$ if $\sigma_x$ = 350 GPa, $\sigma_y$ = − 150 GPa

$\tau_{xy}$ = − 50 GPa, $E$ = 200 GPa

$\mu$ = 0.27

$$\varepsilon_z = \frac{1}{E}\left[\sigma_z - \mu\left(\sigma_x + \sigma_y\right)\right] = \frac{1}{200}\left[0 - 0.27\left(350 - 150\right)\right]$$

$$\varepsilon_z = -0.27$$

*End of Solution*

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**ME** Mechanical Engineering

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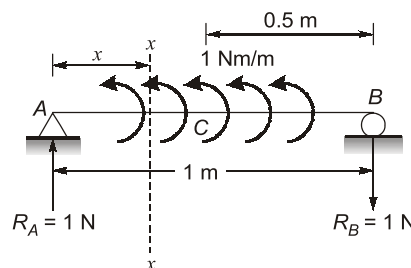*Forenoon Session*

**Q.57** A simply supported beam of length 1 m is subjected to a uniformly distributed bending moment of 1 N m per m throughout the length as shown in the figure given below. The bending moment at the mid-point of the beam is _____N m (rounded off to the nearest integer).
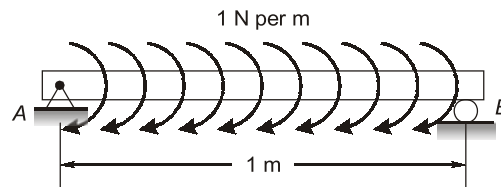


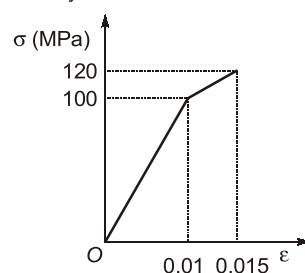**Ans.** **(0)**



$m$ = 1 N-m/m, $L$ = 1 m, $(BM)_C$ = ?

$x$ = 0 to L

$$M_{x\text{-}x} = R_A (x) - mx$$
$$= m(x) - mx = 0$$
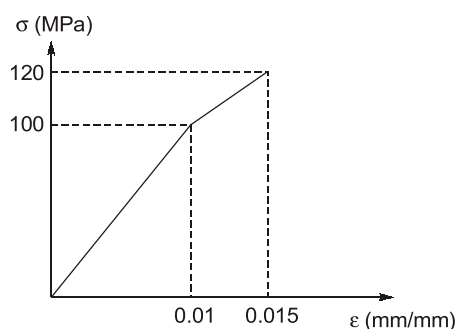
Hence, $(BM)_C = M_C$ = Zero

**Q.58** An isotropic brittle material is tested in the universal testing machine. The stress-strain diagram for the material shows a bi-linear elastic behavior as shown in the figure given below. The strain energy density is _____ MJ m$^{-3}$ (rounded off to 2 decimal places).



**Ans.** **(1 to 1.1)**

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Modulus of resilience = $\dfrac{1}{2} \times 100 \times 0.1 = 0.5 \text{ N}-\text{mm/m}^3$ or MJ/m$^3$

Modulus of toughness = $0.5 + (100 \times 0.005) + \dfrac{1}{2} \times 20 \times 0.005$

$= 1.05$ MJ/m$^3$

**Q.59** A pair of spur gears is required to maintain a velocity ratio of 1:2. The module of the gears is 10 mm and the addendum is 10 mm. If the operating pressure angle is 15°, the minimum number of teeth required on the pinion to ensure NO interference/undercutting is _____ (answer in integer).

**Ans.** **(25)**

$$A_P = A_G = 1$$

$$\text{V.R.} = \dfrac{1}{2}$$

$$\Rightarrow \quad G = 2$$

$$t_{\min} = ??$$

$$T_{\min} = \dfrac{2A_G}{\sqrt{1 + \dfrac{1}{G}\left(\dfrac{1}{G} + 2\right)\sin^2\phi} - 1} = \dfrac{2 \times 1}{\sqrt{1 + \dfrac{1}{2}\left(\dfrac{1}{2} + 2\right)\sin^2 15°} - 1}$$
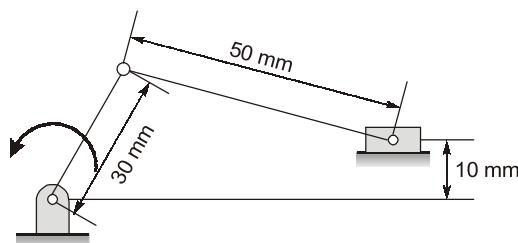
$$T_{\min} = 48.750 = 49$$

$$t_{\min} = \dfrac{T_{\min}}{2} = \dfrac{49}{2} = 24.5 = 25$$

$$t_{\min} = 25$$

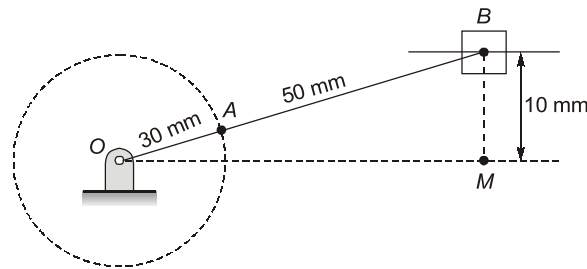**Q.60** An offset slider-crank mechanism is shown in the figure below. The length of the stroke of the slider is _____ mm (rounded off to nearest integer).
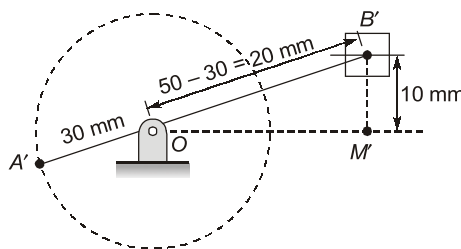
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*Forenoon Session*

**Ans.** **(61 to 63)**



$$OM = \sqrt{80^2 - 10^2}$$
$$= 79.3725 \text{ mm}$$



$$OM' = \sqrt{20^2 - 10^2} = 17.3205$$
$$\text{Stroke} = OM - OM' = 79.3725 - 17.3205$$
$$= 62.0519 \text{ mm}$$

*End of Solution*

**Q.61** Two plates of thickness 10 mm each are to be joined by a transverse fillet weld on one side and the resulting structure is loaded as shown in the figure below.

If the ultimate tensile strength of the weld material is 150 MPa and the factor of safety to be used is 3, the minimum length of the weld required to ensure that the weld does NOT fail is _____ mm (rounded off to 2 decimal places).
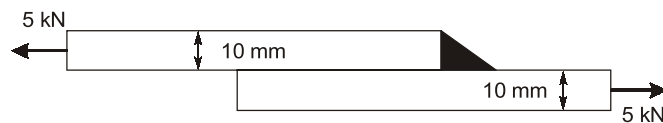


**Ans.** **(14.10 to 14.20 or 21.10 to 28.40 or 34.10 to 34.20)**
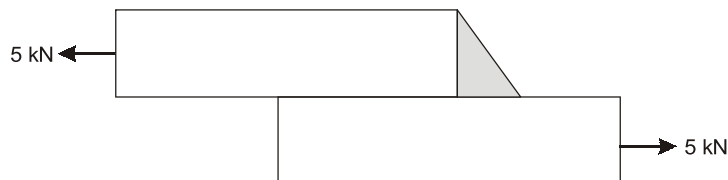


$S_{ys} = 150$ MPa, $N = 3$, $l = ?$

$$P = 0.707 \times t \times l_e \times \frac{S_{ys}}{N}$$
$$5000 = 0.707 \times 10 \times l \times \frac{150}{3}$$

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$$l = 14.14 \text{ mm}$$

Now, if $S_{yt} = 150$ MPa    (as given in some memory based questions)

$$P = 0.707t\, l_e\, \tau_{per}$$

$$P = 0.707t\, l \times \frac{S_{yt}}{2N} \quad (\because\ S_{ys} = \frac{S_{yt}}{2} \text{ and } l_e = l)$$

$$5000 = 0.707 \times 10 \times l \times \frac{150}{2 \times 3}$$

$$\therefore \qquad\qquad l = 28.28 \text{ mm}$$

**Ans:** 14.14 mm if $S_{ys} = 150$ MPa

28.28 mm if $S_{yt} = 150$ MPa

*End of Solution*

---

**Q.62** Two metal parts (a cylinder and a cube) of same volume are cast under identical conditions. The diameter of the cylinder is equal to its height. The ratio of the solidification time of the cube to that of the cylinder is_____ (rounded off to 2 decimal places).

Assume that solidification time follows Chvorinov's rule with an exponent of 2.

**Ans.** **(0.83 to 0.87)**

**Solidification time:**

$$V_{cy} = V_C$$

$$\frac{\pi}{4}d^2 \cdot h = a^3 \qquad\qquad (\because h = d)$$

$$\frac{\pi}{4}d^3 = a^3$$

$$\Rightarrow \qquad\qquad \left(\frac{a}{d}\right) = \left(\frac{\pi}{4}\right)^{1/3}$$

$$\frac{(t_s)_{\text{cube}}}{(t_s)_{\text{cylinder}}} = \frac{\left(\frac{V}{A}\right)^2_C}{\left(\frac{V}{A}\right)^2_{cy}} = \frac{\left(\frac{a}{6}\right)^2}{\left(\frac{d}{6}\right)^2} = \left(\frac{a}{d}\right)^2$$

$$= \left(\frac{\pi}{4}\right)^{2/3} = 0.85$$

*End of Solution*

---

**Q.63** Cylindrical workpieces of diameter 60 mm and length 400 mm are machined on a lathe at a cutting speed of 25 m min⁻¹ and a feed of 0.2 mm rev⁻¹. The Taylor's tool life parameters $C$ and $n$ for this setup are 75 and 0.25, respectively. The tool changing time is 3 minutes. With a labor and overhead cost of Rs. 5 per minute, the tool changing cost per piece is Rs. _____ (rounded off to 2 decimal places).

**Ans.** **(2.65 to 2.95)**

Given:

Diameter of workpiece = 60 mm; Length of workpiece = 400 mm

Cutting speed = 25 m/min;  Feed = 0.2 mm/rev;

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Tool life constant = 75;  Tool life exponent = 0.25;
Tool change time = 3 min;  Labour cost = Rs. 5 per min.
  Tool change cost = $z_1 \times$ number of tool failures/piece $\times$ TCT
$\therefore$  $z_1$ = Rs. 5 per min.

Number of tool failure/piece = $\dfrac{T_m}{T}$

$\therefore$  Machining time, $T_m = \dfrac{L}{f \times N} = \dfrac{400}{0.2 \times \left(\dfrac{1000v}{\pi D}\right)} = \dfrac{400 \times \pi \times 60}{0.2 \times 1000 \times 25} = 15.0857$ min

Tool life, $T = \left(\dfrac{C}{v}\right)^{1/n} = \left(\dfrac{75}{25}\right)^{1/0.25} = 81$ min.

Number of tool failures piece = $\dfrac{15.0857}{81} = 0.1862$

Tool change coster per piece = $5 \times 0.1862 \times 3$
  = Rs, 2.7936

*End of Solution*

**Q.64** A company uses 3000 units of a part annually. The units are priced as given in the table below. It costs Rs. 150 to place an order. Carrying costs are 40 percent of the purchase price per unit on an annual basis. The minimum total annual cost is Rs. _____ (rounded off to 1 decimal place).

| Order quantity | Unit price(Rs.) |
|---|---|
| 1to 499 | 9.0 |
| 500 to 999 | 8.5 |
| 1000 or more | 8.0 |

**Ans.** **(26000 to 26100)**

$D$ = 3000 unit, $C_o$ = ₹150, $C_h$ = 0.4C,

C = ₹8/unit

$$Q^* = \sqrt{\dfrac{2DC_0}{C_h}} = \sqrt{\dfrac{2 \times 3000 \times 150}{0.4 \times 8}}$$
  = 530.33 units/order (Not feasible)

C = ₹8.5/unit

$$Q^* = \sqrt{\dfrac{2DC_0}{C_h}} = 514.49 \text{ units/order (Feasible)}$$

T.C. = $D.C + \dfrac{D}{Q}C_0 + \dfrac{Q}{2}C_h$

T.C.(514.49) = ₹27249.28
T.C.(1000) = ₹26050
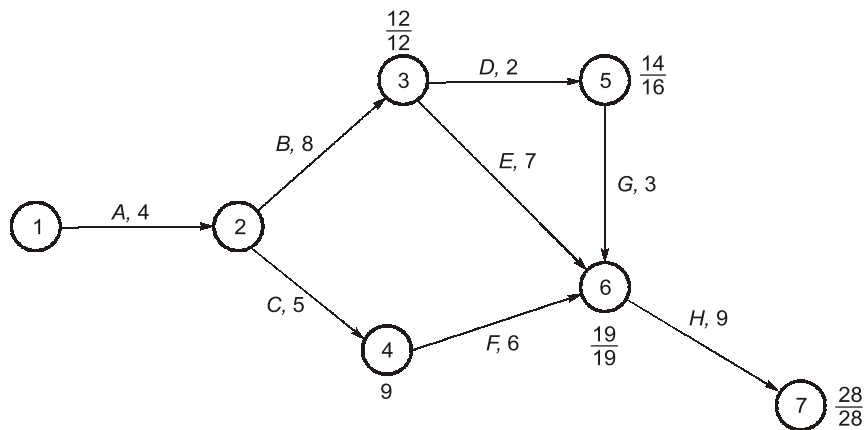
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**Q.65** A project involves eight activities with the precedence relationship and duration as shown in the table below. The slack for the activity D is _____ hours (answer in integer).

| Activity | Immediate predecessor | Duration(hours) |
|----------|----------------------|-----------------|
| A | – | 4 |
| B | A | 8 |
| C | A | 5 |
| D | B | 2 |
| E | B | 7 |
| F | C | 6 |
| G | D | 3 |
| H | E,F,G | 9 |

**Ans.** (2)



$$TES = 0 \quad \text{(Tail Event Slack)}$$
$$HES = 2 \quad \text{(Head Event Slack)}$$
$$s_j = L_j - E_j$$
$$(TF)_D = 16 - 2 - 12 = 2$$
By using, $\quad (TF) = LFT - t_{ij} - EST$

*End of Solution*

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