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Time: 90 Minutes	**PST-2018**	Maximum Marks: 50

Read the following instructions carefully

(1) This question paper contains MCQ and numerical type questions divided into two sections:
   (i) Section I – Question number 01 to 10 (10 Questions) will carry one mark each.
   (ii) Section II – Question number 11 to 30 (20 Questions) will carry two mark each.

(2) Answer all the questions.

(3) Question must be answered on special machine gradable Objective Response Sheet (ORS) by darkening the appropriate bubble (marked A, B, C, D) using black ink ball pen against the question number on the ORS. Each question has only one correct answer.

(4) Wrong answer carries negative marks. For one mark, there is one-third negative mark. For, two mark two-third negative mark. No negative marking for numerical type questions.

(5) More than one answer bubbled against the question will be deemed as an incorrect response.

(6) Write your registration number and other details at the specified locations on the ORS.

(7) Calculator is allowed in the examination hall but the programmable calculator is not permitted.

(8) Charts, graph sheets or tables are not allowed.

(9) Choose the closest numerical answer among the choice given.

(10) Use the blank pages given at the end of the question paper for rough use.

(11) Cellphones, mobile phones are prohibited in the examination hall.

(12) This question paper contains 12 printed pages including pages for rough work.

(13) Please check all pages and report if there is any discrepancy.

Candidate Name:_____

Registration Number:_____

Branch: ME,AE,PI

Paper Code: 102

SECTION-A

[Q-1] A rod of length L and diameter D is subjected to a tensile load P. Which of the following is sufficient to calculate the resulting change in diameter? **[GATE-2008]**
   (a) Young's modulus
   (b) Shear modulus
   (c) Poisson's ratio
   (d) Both Young's modulus and shear modulus

[Q-2] For a ductile material, toughness is a measure of……. **[GATE-2013]**
   (a) resistance to scratching
   (b) ability to absorb energy up to fracture
   (c) ability to absorb energy till elastic limit
   (d) resistance to indentation

[Q-3] Heat and work are… **[GATE-2011]**
   (a) intensive properties   (b) extensive properties
   (c) point functions   (d) path function

[Q-4] The order and degree of the differential equation $\frac{d^3y}{dx^3} + 4\sqrt{\left(\frac{dy}{dx}\right)^3 + y^2} = 0$ are respectively?
  (a) 3 and 2   (b) 2 and 3   (c) 3 and 3   (d) 3 and 1 **[GATE-2010]**

[Q-5] Cost of 3 cricket balls = cost of 2 pairs of leg pads.
   Cost of 3 pairs of leg pads = cost of 2 pairs of gloves.
   Cost of 3 pairs of gloves = cost of 2 cricket bats.
   If a cricket bat costs Rs. 54, what is the cost of a cricket ball?
   (a) Rs. 12   (b) Rs. 14   (c) Rs. 16   (d) Rs. 18

[Q-6] A metallic rod of 500 mm length and 50 mm diameter, when subjected to a tensile force of 100 kN at the ends, experiences an increase in its length by 0.5 mm and a reduction in its diameter by 0.015 mm. The Poisson's ratio of the rod material is………
[GATE-2014]

[Q-7] Cutting tools are provided with large positive rake angle mainly for…..   **[GATE-1987]**
    (a) Increasing the strength of the cutting edge
    (b) Avoiding rubbing action with the finished surfaces
    (c) Reducing the magnitude of the cutting force
    (d) Better heat dissipation

[Q-8] For reversible adiabatic compression in a steady flow process, the work transfer per unit mass is……   **[GATE-1996]**
    (a) $\int pdv$ (b) $\int vdp$ (c) $\int Tds$ (d) $\int sdT$

[Q-9] Match List-I with List-ii and select the correct answer using the codes given below the lists:

List-I	List-II
A. Singular matrix	1. Determinant is not defined
B. Non-square matrix	2. Determinant is always one
C. Real symmetric	3. Determinant is zero
D. Orthogonal matrix	4. Eigen value are always real
	5. Eigen value are not defined

[GATE-2006]

Codes:
	A	B	C	D
(a)	3	1	4	2
(b)	2	3	4	1
(c)	3	2	5	4
(d)	3	4	2	1

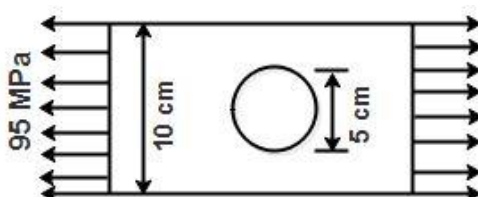**[Q-10]** A can do a piece of work in 10 days and B can do the same work in 20 days. With the help of C, they finish the work in 5 days. How long will it take for C alone to finish the work?
    (a) 20 days   (b) 10 days   (c) 35 days   (d) 15 days

SECTION-B

[Q-11] A large uniform plate containing a rivet hole is subjected to uniform uniaxial tension of 95 MPa. The maximum stress in the plates is…..   **[GATE-1992]**

    (a) 100 MPa   (b) 285 MPa   (c) 190 MPa   (d) Indetermine

[Q-12] Match the following   **[GATE-1995]**

Manufacturing process	Condition
A. Finish turning	1. Backlash eliminator
B. Forming	2. Zero rake
C. Thread cutting	3. Nose radius
D. Down milling	4. Low speed

Codes: A   B   C   D   A   B   C   D
   (a)   3   4   2   1 (b) 2   4   3   1
   (c)   4   2   3   1 (d) 1   2   3   4

[Q-13] A certain amount of an ideal gas is initially at a pressure P_1 and temperature T_1. First , it undergoes a constant pressure process 1-2 such that $T_2 = 3T_1/4$. Then, it undergoes a constant volume process 2-3 such that $T_3 = T_1/2$. The ratio of the final volume to the initial volume of the ideal gas is…….

   (a) 0.25   (b) 0.75   (c) 1.0   (d) 1.5   **[GATE-2014]**

[Q-14] The rank of the matrix $\begin{bmatrix} 6 & 0 & 4 & 4 \\ -2 & 14 & 8 & 18 \\ 14 & -14 & 0 & -10 \end{bmatrix}$ is……..   **[GATE-2014]**

[Q-15] 5 skilled workers can build a wall in 20 days; 8 semiskilled workers can build a wall in 25 days; 10 unskillesd workers can build a wall in 30 days. If a team has 2 skilled, 6 semiskilled and 5 unskilled workers, how long will it take to build the wall?

   (a) 20 days   (b) 18 days   (c) 16 days   (d) 15 days   **[GATE-2010]**

[Q-16] A bar having a cross-sectional area of 700 mm^2 is subjected to axial loads at the positions indicated. The value of stress in the segment QR is……   **[GATE-2006]**
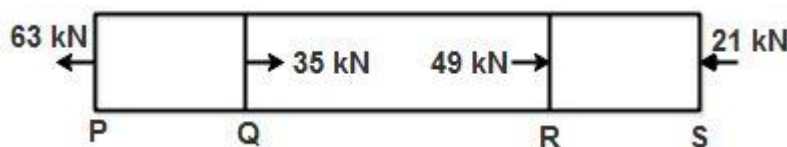
   (a) 40 MPa   (b) 50 MPa   (c) 70 MPa   (d) 120 MPa

[Q-17] The time taken to drill a hole through a 25 mm thick plate with the drill rotating at 300 rpm and moving at a feed rate of 0.25 mm/rev is…..   **[GATE-2002]**

   (a) 10 sec   (b) 20 sec   (c) 60 sec   (d) 100 sec

5

[Q-18] Steam at an initial enthalpy of 100 kJ/kg and inlet velocity of 100 m/s, enters an insulated horizontal nozzle. It leaves the nozzle at 200 m/s. the exit enthalpy (in kJ/kg) is… **[GATE-2016]**

[Q-19] The $\lim_{x\to 0} \frac{\sin\left[\frac{2}{3}x\right]}{x}$ is……. **[GATE-2010]**
    (a) 2/3   (b) 1   (c) 3/2   (d) ∞

[Q-20] A container originally contains 10 litres of pure spirit. From this container 1 litre of spirit is replaced with 1 litre of water. Subsequently, 1 litre of the mixture is again replaced with 1 litre of water and this processes is repeated one more time. How much spirit is now left in the container? **[GATE-2011]**
   (a) 7.58 litres   (b) 7.84 litres   (c) 7 litres   (d) 7.29 liters

[Q-21] The state of plane-stress at a point is given by $\sigma_x = 200$ MPa, $\sigma_y = 100$ MPa and $\tau_{xy} = 100$ MPa. The maximum shear stress (in MPa) is……. **[GATE-2010]**
  (a) 111.8   (b) 150.1   (c) 180.3   (d) 223.6

[Q-22] If the index crank of a dividing head is turned through one complete revolution and 10 holes in a 30 hole circle plate, the workpiece turns through (in degrees)
  (a) 6   (b) 12   (c) 240   (d) 480   **[GATE-1992]**

[Q-23] Hot hardness in an essential property for……. **[GATE-1995]**
  (a) Gear materials   (b) Shaft materials   (c) Welding electronics   (d) Tool materials

[Q-24] With initial condition x(1) = 0.5, the solution of the differential equation. $t\frac{dx}{dt} + x = t$ is
  (a) $x = t - \frac{1}{2}$ (b) $x = t^2 - \frac{1}{2}$ (c) $x = \frac{t^2}{2}$ (d) $x = \frac{t}{2}$ **[GATE-2012]**

[Q-25] The salaries of A and B together amount to Rs. 2000. A spends 95% of his salary and B, 85% of his salary. If now, their savings are same, what is A's salary?
  (a) Rs. 1500   (b) Rs. 1250   (c) Rs. 750   (d) Rs. 1600

[Q-26] Consider a refrigerator and a heat pump working on the reversed Carnot cycle between the same temperature limits. Which of the following is correct?
  (a) COP of refrigerator = COP of heat pump
  (b) COP of refrigerator = COP of heat pump +1
  (c) COP of refrigerator = COP of heat pump – 1
  (d) COP of refrigerator = Inverse of the COP of heat pump   **[GATE-1995]**

[Q-27] A firm is selling it product at Rs. 60/unit. The total cost of production is Rs. 100 and firm is earning total profit of Rs. 500, later the total cost increased by 30%. By what percentage the price should be increased to maintain the same profit level…
(a) 5   (b) 15   (c) 10   (d) 30   **[GATE-2013]**

[Q-28] If the Poisson's ratio of an elastic material is 0.4, the ratio of modulus of rigidity to Young's modulus is…….   **[GATE-2014]**

[Q-29] A mixture contains alcohol and water in the ratio of 12 : 5. On adding 14 litres of water, the ratio of alcohol to water becomes 4 : 3. The quantity of alcohol in the mixture is….

[Q-30] A heat pump absorbs 10 kW of heat from outside environment at 250K while absorbing 15 kW of work. It delivers the heat to a room that must be kept warm at 300 K. The coefficient of performance (COP) of the heat pump is…………   **[GATE-2017]**

ANSWER KEY

Q.	ANS	Q.	ANS	Q.	ANS	Q.	ANS
Q-1	[D]	Q-9	[A]	Q-17	[B]	Q-25	[A]
Q-2	[D]	Q-10	[A]	Q-18	85	Q-26	[C]
Q-3	[D]	Q-11	[C]	Q-19	[A]	Q-27	[A]
Q-4	[A]	Q-12	[A]	Q-20	[D]	Q-28	0.35 to 0.36
Q-5	[C]	Q-13	[B]	Q-21	[A]	Q-29	42 L
Q-6	0.3	Q-14	2	Q-22	[B]	Q-30	1.67
Q-7	[C]	Q-15	[D]	Q-23	[D]	-	-
Q-8	[B]	Q-16	[A]	Q-24	[D]	-	-

SOLUTION

[Q-4] $\frac{d^3y}{dx^3} + 4\sqrt{\left(\frac{dy}{dx}\right)^3 + y^2} = 0$ Removing radicals we get $\left(\frac{d^3y}{dx^3}\right)^2 = 16\left[\left(\frac{dy}{dx}\right)^3 + y^2\right]$

The order is 3 since highest differential is $\frac{d^3y}{dx^3}$

The degree is 2 since power of highet differential is 2.

[Q-5] $3G = 54 \times 2 = 108 \Rightarrow G = 36$

$3P = 36 \times 2 = 72 \Rightarrow P = 24$

$3C = 24 \times 2 = 48 \Rightarrow C = 16$

Cost of a cricket ball = Rs. 16

[Q-6] $v = -\frac{Lateral\ strain}{Longitudinal\ strain} = -\frac{\left(\frac{\Delta D}{D}\right)}{\left(\frac{\Delta L}{L}\right)}$

$v = \left(\frac{L}{D}\right)\left(-\frac{\Delta D}{\Delta L}\right)$

Given, L = 500 mm, D = 50 mm

$\Delta D = -0.015,\ \Delta L = +0.5\ mm$

$\therefore\ v = \frac{500}{50} \times \frac{0.015}{0.500} = 0.3$

[Q-10] $\frac{1}{5} - \frac{1}{10} - \frac{1}{20} = \frac{1}{20}$

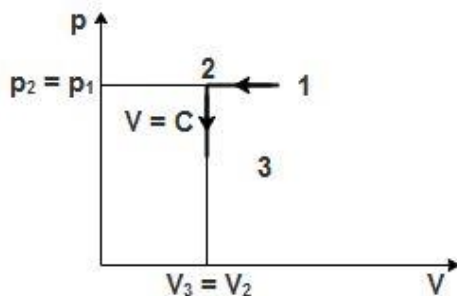This is C's one day work so 20 days are required for C alone to finish task

[Q-11] Tensile load acting on the plate, P = 95 x 10 x t = 9500t N

Maximum stress in the plate, $\sigma_{max} = \frac{P}{(b-d)t} = \frac{9500t}{(100-50)t}$

$= \frac{9500t}{50t} = 190$ MPa.

[Q-13]

Process 1 – 2 : Cooling at p = C

$T = \frac{3T_1}{4}$ given condition or $\frac{T_2}{T_1} = \frac{3}{4}$

According to Charl's law

$\frac{V_2}{V_1} = \frac{T_2}{T_1} = \frac{3}{4}$

Process 2 – 3 : Cooling at V = C

$T_3 = \frac{T_2}{2}$ given condition

$\frac{Final\ volume}{Initial\ volume} = \frac{V_3}{V_1} = \frac{V_2}{V_1}$ $\because V_3 = V_2$

$= \frac{3}{4} = 0.75$

[Q-14] $\begin{bmatrix} 6 & 0 & 4 & 4 \\ -2 & 14 & 8 & 18 \\ 14 & -14 & 0 & -10 \end{bmatrix}$

$R_3 \to R_3 - 2R_1 + R_2$

$\begin{bmatrix} 6 & 0 & 4 & 4 \\ -2 & 14 & 8 & 18 \\ 14-2(6)+(-2) & -14-2(0)+(14) & 0-2(4)+8 & -10-2(4)+(18) \end{bmatrix}$

$\begin{bmatrix} 6 & 0 & 4 & 4 \\ -2 & 14 & 8 & 18 \\ 0 & 0 & 0 & 0 \end{bmatrix}$

Determinant of matrix $\begin{bmatrix} 6 & 0 \\ -2 & 14 \end{bmatrix}$ is not zero, So Rank is 2

[Q-15] Per day work or rate of 5 skilled workers $= \dfrac{1}{20}$

Per day work or rate of one skill worker $= \dfrac{1}{5\times20} = \dfrac{1}{100}$

Similarly per day work or rate 8 semiskilled workers $= \dfrac{1}{25}$

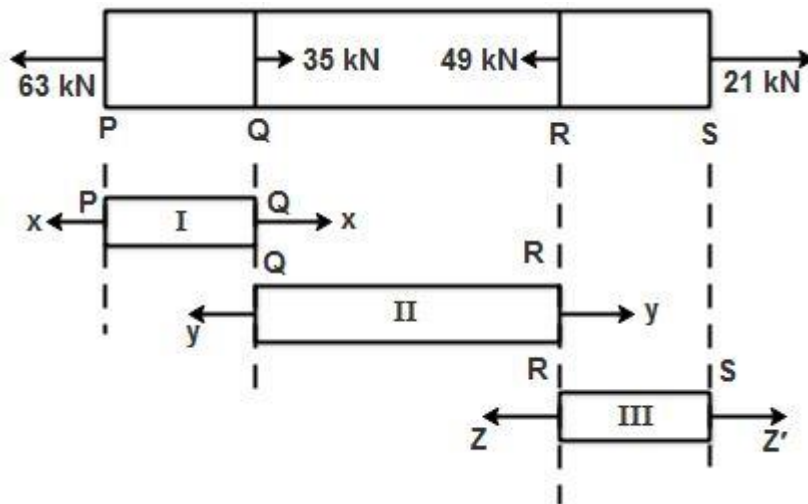Per day work or rate of one semi-skill worker $= \dfrac{1}{8\times25} = \dfrac{1}{200}$

And per day work or rate of 10 unskilled workers $= \dfrac{1}{30}$

Per day work or rate of one un-skill worker $= \dfrac{1}{10\times30} = \dfrac{1}{300}$

Thus total per day work of 2 skilled, 6 semiskilled and 5 unskilled workers

$= \dfrac{2}{100} + \dfrac{6}{200} + \dfrac{5}{300} = \dfrac{12+18+10}{600} = \dfrac{40}{600} = \dfrac{1}{15}$ Thus time to complete the work is 15 days.

[Q-16]

At face Q 35 kN force is acting towards right hence (x > y)

$\therefore x - y = 35\ kN$

At face R 49 kN force is acting toward right hence (y > z)

X = 63 kN [on compairing P face of bar and P face of I]

If   x = 63 kN

x – y = 35 kN

y = 28 kN

If   y = 28 kN

y – z = 49 kN

z = −21 kN

$\sigma_{QR} = \dfrac{28\times10^3\,N}{700\ mm^2} = 40$ MPa

[Q-18]
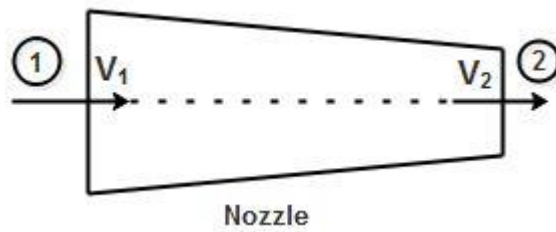
Nozzle

Applying steady flow energy equation between section 1 and 2

$$h_1 + \frac{V_1^2}{2} + gz_1 + q = h_2 + \frac{V_2^2}{2} + gz_2 + W$$

Where　q = 0　insulated nozzle

$Z_1 = Z_2$　horizontal nozzle

W = 0　always for nozzle

$$h_1 + \frac{V_1^2}{2} = h_2 + \frac{V_2^2}{2}$$

$$h_1 + \frac{V_1^2}{2000} = h_2 + \frac{V_2^2}{2000}$$

Where h_1 and h_2 are in kJ/kg and V_1 and V_2 are in m/s

$$\therefore 100 + \frac{(100)^2}{2000} = h_2 + \frac{(200)^2}{2000}$$

100 + 5 = h_2 + 20

Or　　h_2 = 85 kJ/kg

[Q-19] $\lim_{x \to 0} \dfrac{\sin\left[\frac{2}{3}x\right]}{x} = \lim_{\frac{2}{3}x \to 0} \dfrac{\sin\left(\frac{2}{3}x\right)}{\frac{2}{3}x} \cdot \dfrac{2}{3}$

$$= (1)\left(\frac{2}{3}\right) = \frac{2}{3}$$

[Q-20] Every time if we take 1 litre of mixture out and replaced with water, content of pure spirit will keep on reducing by 10 %.

So, final quantity of spirit after 3 such operations are

10 x 0.9 x 0.9 x 0.9 = 7.29 litres

[Q-21]　　In plane, $\tau_{max} = \frac{1}{2}\sqrt{\left(\sigma_x - \sigma_y\right)^2 + 4\ \tau_{xy}^2}$

$$= \frac{1}{2}\sqrt{100^2 + 4 \times 100^2}$$

= 111.8033 MPa

[Q-24] The given differential equation is $t\frac{dx}{dt} + x = t$ with initial condition $x(1) = \frac{1}{2}$ which is same as $\frac{dx}{dt} + \frac{x}{t} = 1$

Which is a linear differential equation

$\frac{dx}{dt} + Px = Q$ where $P = \frac{1}{t}$ and Q = 1

Integrating factor

$= e^{\int P dt} = e^{\int \frac{1}{t} dt}$

$= e^{\log_e t} = t$

Solution is $x \cdot (IF) = \int Q \cdot (IF) dt + C$

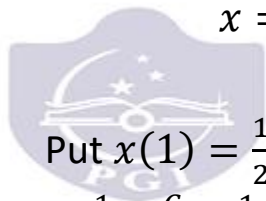$x \cdot t = \int 1 \cdot t \cdot dt + C$

$xt = \frac{t^2}{2} + C$

$x = \frac{t}{2} + \frac{C}{t}$

Put $x(1) = \frac{1}{2}$

$\Rightarrow \frac{1}{2} + \frac{C}{1} = \frac{1}{2}$

$\Rightarrow C = 0$

So, $x = \frac{t}{2}$ is the solution

[Q-25] Let A's salary = x, then B's = (2000 – x)

5% of A = 15% of B, i.e.
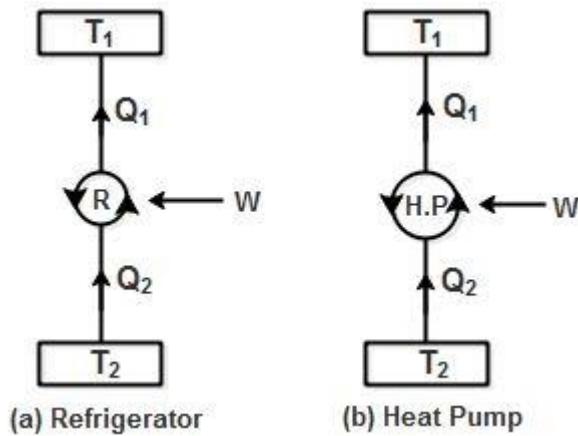
$\frac{5}{100}x = \frac{15}{100}(2000 - x)$ *or* $x = 1500$

[Q-26] Refrigerator:

Coefficient of performance of regreator,

$$(COP)_R = \frac{Cooling\ effect : Q_2}{Work\ input : W}$$

$$= \frac{Q_2}{W}$$

(a) Refrigerator   (b) Heat Pump

Heat Pump:

Coefficient of performance of heat pump,

$$(COP)_{HP} = \frac{Heating\ effect : Q_1}{Work\ input : W}$$

$$(COP)_{HP} = \frac{Q_1}{W}$$

$$(COP)_{HP} = \frac{Q_1 - Q_2 + Q_2}{W}$$

$$(COP)_{HP} = \frac{W + Q_2}{W} \qquad \because W = Q_1 - Q_2$$

$$(COP)_{HP} = 1 + \frac{Q_2}{W}$$

$$(COP)_{HP} = 1 + (COP)_R$$

Or $(COP)_R = (COP)_{HP} - 1$

[Q-28] $\quad E = 2G(1 + v)$

$$\frac{G}{E} = \frac{1}{2(1+v)} = \frac{1}{2 \times 1.4} = \frac{1}{2.8} = 0.357$$

[Q-29] Ratio of alcohol and water 12 : 5

Let their qualities be 12x and 5x respectively.

After adding the litres of water ratio becomes 4 : 3
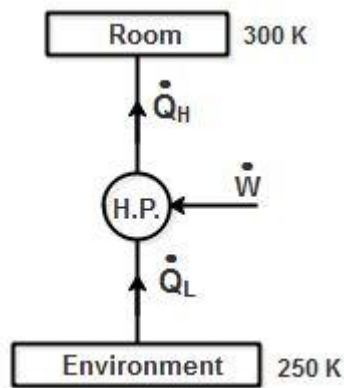
$$\frac{12x}{5x+14} = \frac{4}{3}$$

$$x = \frac{7}{2}$$

Quantity of alcohol = $12 \times \frac{7}{2} = 42\ litres$.

[Q-30]　　　　Given that $\dot{Q}_L = 10 \; kW$

$\dot{W} = 15 \; kW$

Applying first law on heat pump

$$\dot{Q}_L + \dot{W} = \dot{Q}_H$$
$$10 \; kW + 15 \; kW = \dot{Q}_H$$
$$\dot{Q}_H = 25 \; kW$$
$$(COP)_{H.P.} = \frac{\dot{Q}_H}{H} = \frac{25 \; kW}{15 \; kW} = 1.67$$