GATE

Previous Year Questions

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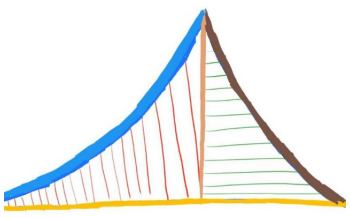

Contents

Introduction

This book contains a typed GATE question set.

Chapter 1

2007

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PH

3.1 The value of the contour integral, $\left|\int_C \overrightarrow{r} \times d\overrightarrow{\theta}\right|$, for a circle C of radius r with center at origin is

(a) $2\pi r$

(b) $r^2/2$

(c) πr^2

(d) r

3.2 An electrostatic field $\overrightarrow{E}$ exists in a given region R. Choose the WRONG statement.

(a) Circulation of $\overrightarrow{E}$ is zero

(b) $\overrightarrow{E}$ can always be expressed as the gradient of a scalar field

(c) The potential difference between any two arbitrary points in the region R is zero

(d) The work done in a closed path lying entirely in R is zero

3.3 The Lagrangian of a free particle in spherical polar co-ordinates is given by $L = \frac{1}{2}m\left(\dot{r}^2 + r^2\dot{\theta}^2 + r^2\dot{\phi}^2\sin^2\theta\right)$. The quantity that is conserved is

(a) $\frac{\partial L}{\partial \dot{r}}$

(b) $\frac{\partial L}{\partial \dot{\theta}}$

(c) $\frac{\partial L}{\partial \dot{\phi}}$

(d) $\frac{\partial L}{\partial \dot{\phi}} + \dot{r}\dot{\theta}$

3.4 A conducting loop L of surface area S is moving with a velocity $\overrightarrow{v}$ in a magnetic field $\overrightarrow{B}(\overrightarrow{r}, t)$=$\overrightarrow{B_0}t^2$, B_o is a positive constant of suitable dimensions. The emf induced, V_{emf}, in the loop is given by

(a) -$\int_S \frac{\partial \overrightarrow{B}}{\partial t} \cdot d\overrightarrow{S}$

(b) $\oint_L (\overrightarrow{v} \times \overrightarrow{B}) \cdot d\overrightarrow{L}$

(c) -$\int_S \frac{\partial \overrightarrow{B}}{\partial t} \cdot d\overrightarrow{S}$-$\oint_L (\overrightarrow{v} \times \overrightarrow{B}) \cdot d\overrightarrow{L}$

(d) -$\int_S \frac{\partial \overrightarrow{B}}{\partial t} \cdot d\overrightarrow{S}$+$\oint_L (\overrightarrow{v} \times \overrightarrow{B}) \cdot d\overrightarrow{L}$

3.5 The eigenvalues of the matrix $A = \begin{bmatrix} 0 & i \\ i & 0 \end{bmatrix}$ are

(a) real and distinct

(b) complex and distinct

(c) complex and coinciding

(d) real and coinciding

3.6 $\sigma_i (i = 1, 2, 3)$ represent the Pauli spin matrices. Which one of the following is NOT true ?

(a) $\sigma_i\sigma_j$+$\sigma_j\sigma_i$=$2\delta_{ij}$

(b) $Tr(\sigma_i) = 0$

(c) The eigenvalues of σ_i are ± 1

(d) $\det(\sigma_i)$=1

3.7 Which one of the functions given below represents the bound state eigenfunction of the operator $-\frac{d^2}{dx^2}$ in the region, $0 \leq x < \infty$ with the eigenvalue -4 ?

(a) $A_o e^{2x}$

(b) $A_o \cosh 2x$

(c) $A_o e^{-2x}$

(d) $A_o \sinh 2x$

3.8 Pick the WRONG statement.

(a) The nuclear force is independent of electric charge

(b) The Yukawa potential is proportional to $r^{-1} \exp\left(\frac{mc}{\hbar} r\right)$, where r is the separation between two nucleons

(c) The range of nuclear force is order of $10^{-15}m - 10^{-14}m$

(d) The nucleons interact among each other by the exchange of mesons

3.9 If p and q are the position and momentum variables, which one of the following is NOT a canonical transformation ?

(a) $Q = \alpha q$ and $P = \frac{1}{\alpha} p$, for $\alpha \neq 0$

(b) $Q = \alpha q + \beta p$ and $P = \beta q + \alpha p$ for α, β real and $\alpha^2 - \beta^2 = 1$

(c) $Q = p$ and $P = q$

(d) $Q = p$ and $P = -q$

3.10 The Common Mode Rejection Ratio (CMRR) of a differential amplifier using an operational amplifier is 100 dB. The output voltage for a differential input of 200 μV is 2 V. The common mode gain is

(a) 10

(b) 0.1

(c) 30 dB

(d) 10 dB

3.11 In an insulating solid which one of the following physical phenomena is a consequence of Pauli's exclusion principle ?

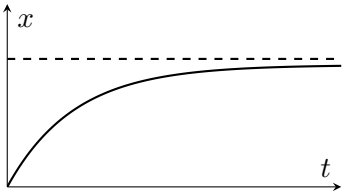
(a) Ionic conductivity

(b) Ferromagnetism

(c) Paramagnetism

(d) Ferroelectricity

3.12 Which one of the following curves gives the solution of the differential equation $k_1 \frac{dx}{dt} + k_2 x = k_3$, where k_1, k_2 and k_3 are positive constants with initial conditions $x = 0$ at $t = 0$?

(a)


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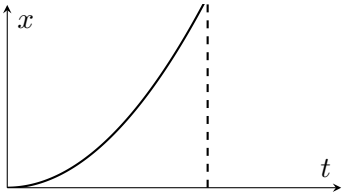

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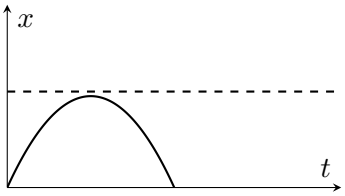
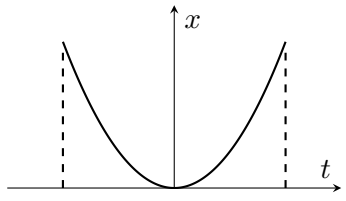


(d) 

Chapter 4

2010

Chapter 5

2011

ME

5.1 The maximum deflection of the beam

(a) $\frac{24Pl^3}{Ebt^3}$

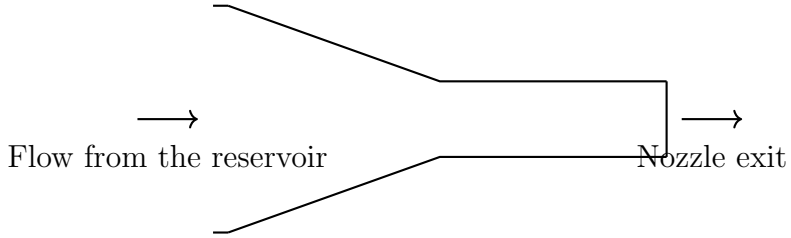
(b) $\frac{12Pl^3}{Ebt^3}$

(c) $\frac{8Pl^3}{Ebt^3}$

(d) $\frac{6Pl^3}{Ebt^3}$

Statement for Linked Answer Questions 54 and 55:

The temperature and pressure of air in a large reservoir are 400 K and 3 bar respectively. A converging- diverging nozzle of exit area $0.005m^2$ is fitted to the wall of the reservoir as shown in the figure. The static pressure of air at the exit section for isentropic flow through the nozzle is 50 kPa. The characteristic gas constant and the ratio of specific heats of air are 0.287 kJ/kgK and 1.4 respectively.



5.2 The density of air in kg/m^3 at the nozzle exit is

(a) 0.560

(b) 0.600

(c) 0.727

(d) 0.800

5.3 The mass flow rate of air through the nozzle in kg/s is

(a) 1.30

(b) 1.77

(c) 1.85

(d) 2.06

5.4 Choose the word from the options given below that is most nearly opposite in meaning to the given word:

Amalgamate

(a) merge

(b) split

(c) collect

(d) separate

5.5 Which of the following option is the closest in the meaning to the word below:

Inexplicable

(a) Incomprehensible

(b) Indelible

(c) Inextricable

(d) Infallible

5.6 If Log (P) = (1/2)Log (Q) = (1/3) Log (R), then which of the following options is TRUE?

(a) $P^2 = Q^3R^2$

(b) $Q^2 = PR$

(c) $Q^2 = R^3P$

(d) $R = P^2Q^2$

5.7 Choose the most appropriate word(s) from the options given below to complete the following sentence.

I contemplated _____ Singapore for my vacation but decided against it.

(a) to visit

(b) having to visit

(c) visiting

(d) for a visit

5.8 Choose the most appropriate word from the options given below to complete the following sentence.

If you are trying to make a strong impression on your audience, you cannot do so by being understated, tentative or _____.

(a) hyperbolic

(b) restrained

(c) argumentative

(d) indifferent

Q.61 to Q.65 carry two marks each.

5.9 A container originally contains 10 liters of pure spirit. From this container 1 liter of spirit is replaced with 1 liter of water. Subsequently, 1 liter of the mixture is again replaced with 1 liter of water and this process is repeated one more time. How much spirit is now left in the container?

(a) 7.58 liters

(b) 7.84 liters

(c) 7 liters

(d) 7.29 liters

5.10 **Few school curricula include a unit on how to deal with bereavement and grief, and yet all students at some point in their lives suffer from losses through death and parting.**

Based on the above passage which topic would not be included in a unit on bereavement?

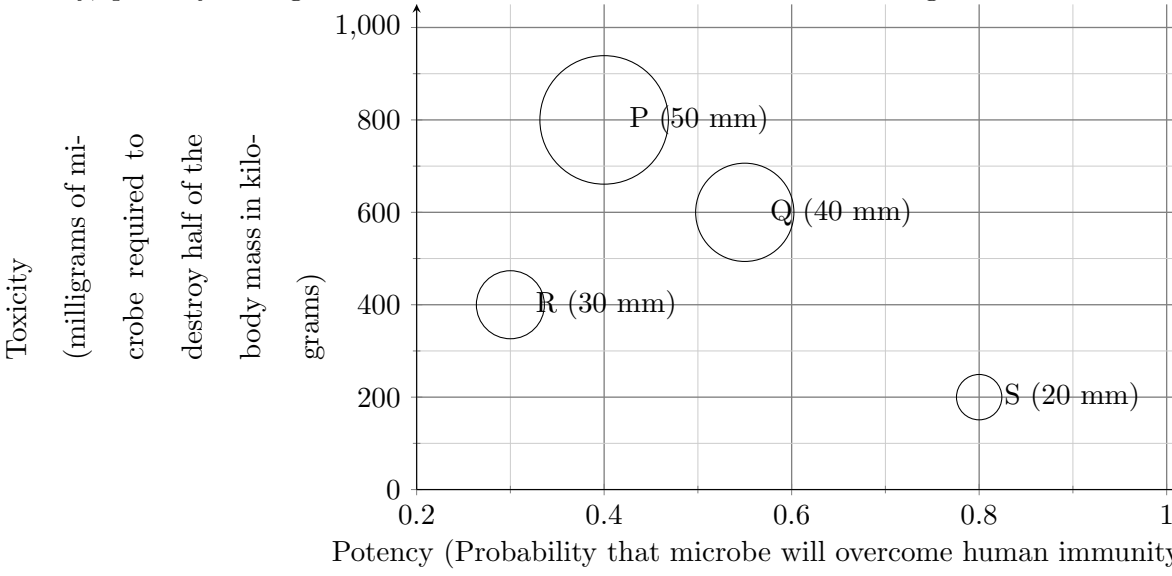
(a) how to write a letter of condolence

(b) what emotional stages are passed through in the healing process

(c) what the leading causes of death are

(d) how to give support to a grieving friend

5.11 P, Q, R and S are four types of dangerous microbes recently found in a human habitat. The area of each circle with its diameter printed in brackets represents the growth of a single microbe surviving human immunity system within 24 hours of entering the body. The danger to human beings varies proportionately with the toxicity, potency and growth attributed to a microbe shown in the figure below.



A pharmaceutical company is contemplating the developement of a vaccine against the most dangerous microbe. Which microbe should the company target in its first attempt?

(a) P

(b) Q

(c) R

(d) S

5.12 The variable cost (V) of manufacturing a product varies according to the equation V= 4q, where q is the quantity produced. The fixed cost (F) of production of same product reduces with q according to the equation F = 100/q. How many units should be produced to minimize the total cost (V+F)?

(a) 5

(b) 4

(c) 7

(d) 6

5.13 A transporter receives the same number of orders each day. Currently, he has some pending orders (backlog) to be shipped. If he uses 7 trucks, then at the end of the 4th day he can clear all the orders. Alternatively, if he uses only 3 trucks, then all the orders are cleared at the end of the 10th day. What is the minimum number of trucks required so that there will be no pending order at the end of the 5th day?

(a) 4

(b) 5

(c) 6

(d) 7

MA

5.1 Let $T : \mathbb{C}^3 \to \mathbb{C}^3$ be defined by $T \begin{pmatrix} z_1 \\ z_2 \\ z_3 \end{pmatrix} = \begin{pmatrix} z_1 - iz_2 \\ iz_1 + z_2 \\ z_1 + z_2 + iz_3 \end{pmatrix}$. Then, the adjoint T^* of T is given by $T^* \begin{pmatrix} z_1 \\ z_2 \\ z_3 \end{pmatrix} =$

(a) $\begin{pmatrix} z_1 + iz_2 \\ -iz_1 + z_2 \\ z_1 + z_2 - iz_3 \end{pmatrix}$

(b) $\begin{pmatrix} z_1 - iz_2 + z_3 \\ -iz_1 + z_2 + z_3 \\ iz_3 \end{pmatrix}$

(c) $\begin{pmatrix} z_1 - iz_2 + z_3 \\ iz_1 + z_2 + z_3 \\ -iz_3 \end{pmatrix}$

(d) $\begin{pmatrix} iz_1 + z_2 \\ z_1 - iz_2 \\ z_1 - z_2 - iz_3 \end{pmatrix}$

5.2 Let $f(z)$ be an entire function that $|f(z)| \leq K|z|, \forall z \in \mathbb{C}$, for some $K > 0$. If $f(1) = i$, the value of $f(i)$ is

(a) 1

(b) -1

(c) i

(d) $-i$

5.3 Let y be the solution of the initial value problem

$$\frac{d^2y}{dx^2} + y = 6\cos 2x,\ y(0) = 3,\ y'(0) = 1.$$

Let the Laplace transform of y be $F(s)$. Then, the value of $F(1)$ is

(a) $\frac{17}{5}$

(b) $\frac{13}{5}$

(c) $\frac{11}{5}$

(d) $\frac{9}{5}$

5.4 For $0 \leq x \leq 1$, let

$$f_n(x) = \begin{cases} \frac{n}{1+n}, & \text{if } x \text{ is irrational} \\ 0, & \text{if } x \text{ is rational} \end{cases}$$

and $f(x) = \lim_{n\to\infty} f_n(x)$. Then, on the interval [0,1]

(a) f is measurable and Riemann integrable

(b) f is measurable and Lebesgue integrable

(c) f is not measurable

(d) f is not Lebesgue integrable

5.5 If x, y and z are positive real numbers, then the minimum value of

$$x^2 + 8y^2 + 27z^2 \text{ where } \frac{1}{x} + \frac{1}{y} + \frac{1}{z} = 1$$

is

(a) 108

(b) 216

(c) 405

(d) 1048

5.6 Let $T : \mathbb{R}^4 \to \mathbb{R}^4$ be defined by

$$T(x, y, z, w) = (x + y + 5w, x + 2y + w, -z + 2w, 5x + y + 2z).$$

The dimension of the eigenspace of T is

(a) 1

(b) 2

(c) 3

(d) 4

5.7 Let y be a polynomial solution of the differential equation

$$(1 - x^2)y'' - 2xy' + 6y = 0.$$

If $y(1) = 2$, then the value of the integral $\int_{-1}^{1} y^2 dx$ is

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

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

(c) $\frac{4}{5}$

(d) $\frac{8}{5}$

5.8 The value of the integral

$$I = \int_{-1}^{1} exp(x^2)dx$$

using a rectangular rule is approximated as 2. Then, the approximation error $|I - 2|$ lies in the interval

(a) $(2e, 3e]$

(b) $(\frac{2}{3}, 2e]$

(c) $(\frac{e}{8}, \frac{2}{3}]$

(d) $(0, \frac{e}{8}]$

5.9 The integral surface for the Cauchy problem

$$\frac{\partial z}{\partial x} + \frac{\partial z}{\partial y} = 1,$$

which passes through the circle $z = 0$, $x^2 + y^2 = 1$ is

(a) $x^2 + y^2 + 2z^2 + 2zx - 2yz - 1 = 0$

(b) $x^2 + y^2 + 2z^2 + 2zx + 2yz - 1 = 0$

(c) $x^2 + y^2 + 2z^2 - 2zx - 2yz - 1 = 0$

(d) $x^2 + y^2 + 2z^2 + 2zx + 2yz + 1 = 0$

5.10 The vertical displacement $u(x, t)$ of an infinitely long elastic string is governed by the initial value problem

$$\frac{\partial^2 u}{\partial t^2} = 4\frac{\partial^2 u}{\partial x^2},\ -\infty < x < \infty,\ t > 0,$$

$$u(x, 0) = -x \text{ and } \frac{\partial u}{\partial t}(x, 0) = 0.$$

The value of $u(x,t)$ at $x=2$ and $t=2$ is equal to

(a) 2

(b) 4

(c) -2

(d) -4

5.11 We have to assign four jobs I, II, III, IV to four workers A, B, C and D. The time taken by different workers (in hours) in completing different jobs is given below:

		I	II	III	IV
Workers	A	5	3	2	8
	B	7	9	2	6
	C	6	4	5	7
	D	5	7	7	8

The optimal assignment is as follows:

Job III to worker A; Job IV to worker B; Job II to worker C and Job I to worker D and hence the time taken by different workers in completing different jobs is now changed as:

		I	II	III	IV
Workers	A	5	3	2	5
	B	7	9	2	3
	C	4	2	3	2
	D	5	7	7	5

Then the minimum time (in hours) taken by the workers to complete all the jobs is

(a) 10

(b) 12

(c) 15

(d) 17

5.12 The following table shows the information on the availability of supply to each warehouse, the requirement of each market and unit transportation cost (in rupees) from each warehouse to each market.

		Market				
		M_1	M_2	M_3	M_4	Supply
	W_1	6	3	5	4	22
Warehouse	W_2	5	9	2	7	15
	W_3	5	7	8	6	8
	Requirement	7	12	17	9	

The present transportation schedule is as follows:
W_1 to M_2: 12 units; W_1 to M_3: 1 unit; $W_1$to M_4: 9 units; W_2 to M_3: 15 units; W_3 to M_1: 7 units and W_3 to M_3: 1 unit. Then the minimum total transportation cost (in rupees) is

(a) 150

(b) 149

(c) 148

(d) 147

5.13 If $\mathbb{Z}[i]$ is the ring of Gaussian integers, the quotient $\mathbb{Z}[i]/(3-i)$ is isomorphic to

(a) $\mathbb{Z}$

(b) $\mathbb{Z}/3\mathbb{Z}$

(c) $\mathbb{Z}/4\mathbb{Z}$

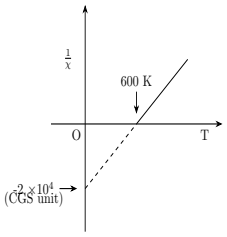
(d) $\mathbb{Z}/10\mathbb{Z}$

Chapter 6

2012

PH

6.1 Inverse susceptibility $\left(\frac{1}{\chi}\right)$ as a function of temperature, T for material undergoing paramagnetic to ferromagnetic transition is given in the figure, where O is the origin. The values of the Curie constant, C, and the Weiss molecular field constant, λ, in CGS units, are



(a) $C = 5 \times 10^{-5},\ \lambda = 3 \times 10^{-2}$

(b) $C = 3 \times 10^{-2},\ \lambda = 5 \times 10^{-5}$

(c) $C = 3 \times 10^{-2},\ \lambda = 2 \times 10^{4}$

(d) $C = 2 \times 10^{4},\ \lambda = 3 \times 10^{-2}$

6.2 A plane polarized electromagnetic wave in free space at time $t = 0$ is given by $\overrightarrow{E}(x, z) = 10j \exp[i(6x + 8z)]$. The magnetic field $\overrightarrow{B}(x, z, t)$ is given by

(a) $\overrightarrow{B}(x,z,t) = \frac{1}{c}\left(6k - 8\hat{i}\right)\exp\left[i\left(6x + 8z - 10ct\right)\right]$

(b) $\overrightarrow{B}(x,z,t) = \frac{1}{c}\left(6k + 8\hat{i}\right)\exp\left[i\left(6x + 8z - 10ct\right)\right]$

(c) $\overrightarrow{B}(x,z,t) = \frac{1}{c}\left(6k - 8\hat{i}\right)\exp\left[i\left(6x + 8z - ct\right)\right]$

(d) $\overrightarrow{B}(x,z,t) = \frac{1}{c}\left(6k + 8\hat{i}\right)\exp\left[i\left(6x + 8z + ct\right)\right]$

6.3 The eigenvalues of the matrix $\begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix}$ are

(a) $0, 1, 1$

(b) 0, $-\sqrt{2}$, $\sqrt{2}$

(c) $\frac{1}{\sqrt{2}}$, $\frac{1}{\sqrt{2}}$, 0

(d) $\sqrt{2}$, $\sqrt{2}$, 0

6.4 Match the typical spectroscopic regions specified in **Group I** with the corresponding type of transitions in **Group II.**

Group I	**Group II**
(P) Infra-red region	(i) electronic transitions involving valence electrons
(Q) Ultraviolet-visible region	(ii) nuclear transitions
(R) X-ray region	(iii) vibrational transitions of molecules
(S) γ-ray region	(iv) transitions involving inner shell electrons

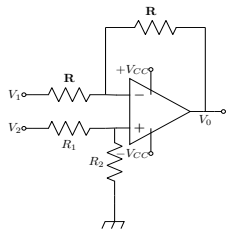
(a) (P,i); (Q,iii); (R,ii); (S,iv)

(b) (P,ii); (Q,iv); (R,i); (S,iii)

(c) (P,iii); (Q,i); (R,iv); (S,ii)

(d) (P,iv); (Q,i); (R,ii); (S,iii)

6.5 In the following circuit, for the output voltage to be $V_o = \left(-V_1 + \frac{V_2}{2}\right)$, the ratio $\frac{R_1}{R_2}$ is



(a) $\frac{1}{2}$

(b) 1

(c) 2

(d) 3

6.6 The terms $\{j_1, j_2\}_J$ arising from $2s^1 3d^1$ electronic configuration in j-j coupling scheme are

(a) $\{\frac{1}{2}, \frac{3}{2}\}_{2,1} \text{and} \{\frac{1}{2}, \frac{5}{2}\}_{3,2}$

(b) $\{\frac{1}{2}, \frac{1}{2}\}_{1,0} \text{and} \{\frac{1}{2}, \frac{3}{2}\}_{2,1}$

(c) $\{\frac{1}{2}, \frac{1}{2}\}_{1,0} \text{and} \{\frac{1}{2}, \frac{5}{2}\}_{3,2}$

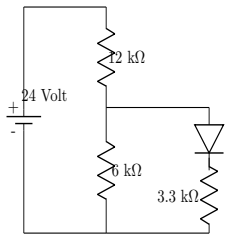
(d) $\{\frac{3}{2}, \frac{1}{2}\}_{2,1} \text{and} \{\frac{1}{2}, \frac{5}{2}\}_{3,2}$

6.7 In the following circuit, the voltage drop across the ideal diode in forward bias condition is $0.7V$.

The current passing through the diode is

(a) 0.5 mA

(b) 1.0 mA



(c) 1.5 mA

(d) 2.0 mA

6.8 Choose the CORRECT statement from the following.

(a) Neutron interacts through electromagnetic interaction

(b) Electron does not interact through weak interaction

(c) Neutrino interacts through weak and electromagnetic interaction

(d) Quark interacts through strong interaction but not through weak interaction

6.9 A rod of proper length l_o oriented parallel to the x-axis moves with speed $\frac{2c}{3}$ along the x-axis in the S-frame, where c is the speed of the light in free space. The observer is also moving along the x-axis with speed $\frac{c}{2}$ with respect to the S-frame. The length of the rod as measured by the observer is

(a) $0.35l_o$

(b) $0.48l_o$

(c) $0.87l_o$

(d) $0.97l_o$

6.10 A simple cubic crystal with lattice parameter a_c undergoes transition into a tetragonal structure with lattice parameters $a_t = b_t = \sqrt{2}a_c$ and $c_t = 2a_c$, below a certain

temperature. The ratio of the interplanar spacings of (1 0 1) planes for the cubic and the tetragonal structure is

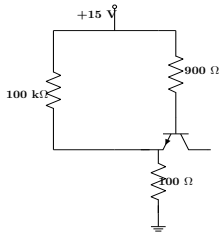
(a) $\sqrt{\frac{1}{6}}$

(b) $\frac{1}{6}$

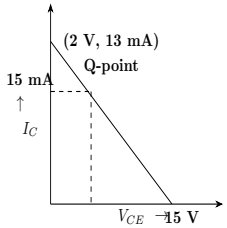
(c) $\sqrt{\frac{3}{8}}$

(d) $\frac{3}{8}$

6.11 Consider the following circuit in which the current gain β_{dc} of the transistor is 100. Which one of the following correctly represents the load line (collector current I_C



with respect to collector-emitter voltage V_{CE}) and Q-point of this circuit?

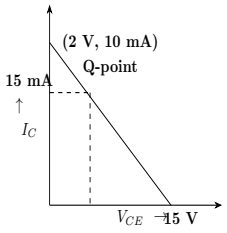


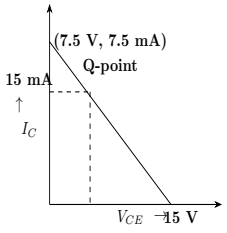
(a)

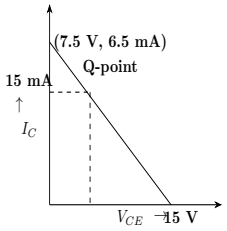
(b)

(c)

(d)







6.12 Consider a system whose three energy levels are given by 0, ϵ and 2ϵ. The energy level ϵ is two-fold degenerate and the other two are non-degenerate. The partition function of the system with $\beta = \frac{1}{k_B T}$

(a) $1 + 2e^{-\beta\epsilon}$

(b) $2e^{-\beta\epsilon} + e^{-2\beta\epsilon}$

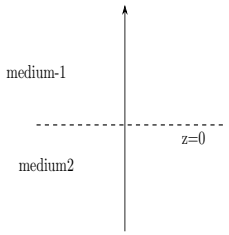
(c) $\left(1 + e^{-\beta\epsilon}\right)^2$

(d) $1 + e^{-\beta\epsilon} + e^{-2\beta\epsilon}$

6.13 Two infinitely extended homogeneous isotropic dielectric media (medium-1 and medium-2 with dielectric constants $\frac{\epsilon_1}{\epsilon_2} = 2$ and $\frac{\epsilon_2}{\epsilon_0} = 5$, respectively) meet at the $z = 0$ plane as shown in the figure . A uniform electric field exists everywhere. For $z \geq 0$, the electric field is given by $\overrightarrow{E_1} = 2\hat{1} - 3j + 5k$. The interface separating the two media is charge

free.

The electric displacement vector in the medium-2 is given by



(a) $\overrightarrow{D_2} = \epsilon_0 \left[10\hat{i} + 15j + 10k\right]$

(b) $\overrightarrow{D_2} = \epsilon_0 \left[10\hat{i} - 15j + 10k\right]$

(c) $\overrightarrow{D_2} = \epsilon_0 \left[4\hat{i} - 6j + 10k\right]$

(d) $\overrightarrow{D_2} = \epsilon_0 \left[4\hat{i} + 6j + 10k\right]$

Chapter 7

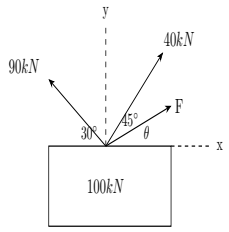
2013

Chapter 8

2014

CE

8.1 A box of weight 100 kN shown in figure is to be lifted without swinging. If all forces are coplanar, the magnitude and direction (θ) of the force (F) with respect to x-axis should be



(a) $F = 56.389kN$ and $\theta = 28.28°$

(b) $F = -56.389kN$ and $\theta = -28.28°$

(c) $F = 9.055kN$ and $\theta = 1.414°$

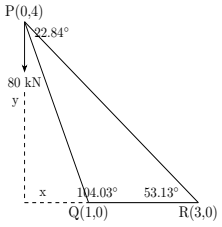
(d) $F = -9.055kN$ and $\theta = -1.414°$

8.2 A particle moves along a curve whose parametric equations are: $x = t^3+2t$, $y = -3e^{-2t}$ and $z = 2\sin 5t$, where x, y and z show variations of the distance covered by the particle (in cm) with time t (in s). The magnitude of the acceleration of the particle

(in $\frac{cm}{s^2}$) at $t = 0$ is _____

8.3 A traffic office imposes on an average 5 number of penalties daily on traffic violators. Assume that the number of penalties on different days is independent and follows a Poisson distribution. The probability that there will be less than 4 penalties in a day is _____

8.4 Mathematical idealization of a crane has three had three bars with their vertices arranged as shown in the figure with a load of 80 kN hanging vertically. The coordinates of the vertices are given in parentheses. The force in the member QR, F_{QR} will be



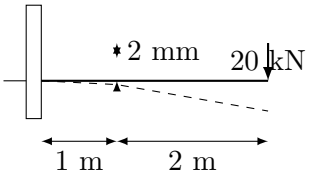
(a) 30 kN Compressive

(b) 30 kN Tensile

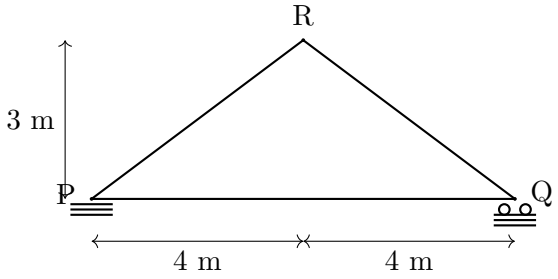
(c) 50 kN Compressive

(d) 50 kN Tensile

8.5 For the cantilever beam of span 3 m (shown below), a concentrated load of 20 kN applied at the free end causes a vertical displacement of 2 mm at a section located at a distance of 1 m from the fixed end. If a concentrated vertically downward load of 10 kN is applied at the section located at a distance of 1 m from the fixed end (with no other load on the beam), the maximum vertical displacement in the same beam (in mm) is _____



8.6 For the truss shown below, the member PQ is short by 3 mm. The magnitude of vertical displacement of joint R (in mm) is _____



8.7 A rectangular beam of width (b) 230 mm and effective depth (d) 450 mm is reinforced with four bars of 12 mm diameter. The grade of concrete is $M20$ and grade of steel is $Fe500$. Given that for $M20$ grade of concrete the ultimate shear strength, $\tau_{uc} = 0.36\ \frac{N}{mm^2}$ for steel percentage, $p = 0.25$, and $\tau_{uc} = 0.48\ \frac{N}{mm^2}$ for $p = 0.50$. For a factored shear force of 45 kN, the diameter (in mm) of $Fe500$ steel two legged stirrups to be used at spacing of 375 mm, should be

(a) 8

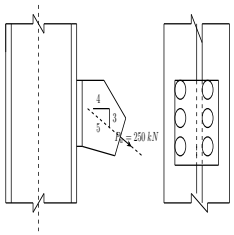
(b) 10

(c) 12

(d) 16

8.8 The tension and shear force (both in kN) in the bolt of the joint, as shown below, respectively are

(a) 30.33 and 20.00



(b) 30.33 and 25.00

(c) 33.33 and 20.00

(d) 33.33 and 25.00

8.9 For a beam of cross-section, width=230 mm and effective depth=500 mm, the number of rebars of 12 mm diameter required to satisfy minimum tension reinforcement requirement specified by $IS : 456-2000$ (assuming grade of steel reinforcement as Fe500) is _____

8.10 In a reinforced concrete section, the stress at the extreme fiber in compression is 5.8 MPa. The depth of neutral axis in the section is 58 mm and the grade of concrete is $M25$. Assuming linear elastic behavior of the concrete, the effective curvature of the section (in per mm)

(a) 2.0×10^{-6}

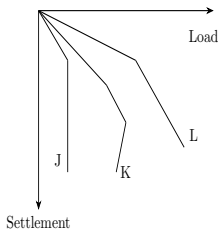
(b) 3.0×10^{-6}

(c) 4.0×10^{-6}

(d) 5.0×10^{-6}

8.11 Group I contains representative load-settlement curves for different modes of bearing capacity failures of sandy soil. Group II enlists the various failure characteristics. Match the load-settlement curves with the corresponding failure characteristics.

Group I	**Group II**
(P) Curve J	(i) No apparent heaving of soil around the footing
(Q) Curve K	(ii) Rankine's passive zone develops imperfectly
(R) Curve L	(iii) Well defined slip surface extends to ground surface



(a) $P-1,\ Q-3,\ R-2$

(b) $P-3,\ Q-2,\ R-1$

(c) $P-3,\ Q-1,\ R-2$

(d) $P-1,\ Q-2,\ R-3$

8.12 A given cohesionless soil has $e_{max} = 0.85$ and $e_{min} = 0.50$. In the field, the soil is compacted to a mass density of 1800 $\frac{kg}{m^3}$ at a water content of 8%. Take the mass density of water as 1000 $\frac{kg}{m^3}$ and G_s as 2.7. The relative density (in %) of the soil is

(a) 56.43

(b) 60.25

(c) 62.87

(d) 65.71

8.13 The following data are given for the laboratory sample.

$\sigma_0' = 175\ kPa;\ e_o = 1.1;\ \sigma_o' + \Delta\sigma_o' = 300\ kPa;\ e = 0.9$

If the thickness of the clay specimen is 25 mm, the value of the coefficient of volume compressibility is _____$\times 10^{-4}$ $\frac{m^2}{kN}$

Chapter 9

2015

Chapter 10

2016

MA

10.1 Let $T:\ l_2 \to l_2$ be defined by

$$T\left((x_1, x_2, \ldots, x_n, \ldots)\right) = (x_2 - x_1, x_3 - x_2, \ldots, x_{n+1} - x_n, \ldots)\,.$$

Then

(a) $||T|| = 1$

(b) $||T|| > 2$ but bounded

(c) $1 < ||T|| \leq 2$

(d) $||T||$ is bounded

10.2 Minimize $w = x + 2y$ subject to

$$2x + y \geq 3$$

$$x + y \geq 2$$

$$x \geq 0,\ y \geq 0.$$

Then, the minimum value of w is equal to _____

10.3 Maximize $w = 11x - z$ subject to

$$10x + y - z \leq 1$$

$$2x - 2y + z \leq 2$$

$$x, y, z \geq 0.$$

Then the maximum value of w is equal to _____

10.4 Let $X_1, X_2, X_3, \ldots$ be a sequence of i.i.d. random variables with mean 1. If N is a geometric random variable with the probability mass function $P(N = k) = \frac{1}{2^k}$; $k = 1, 2, 3, \ldots$ and its independent of the $X_i's$, then $E(X_1 + X_2 + \ldots + X_N)$ is equal to _____

10.5 Let X_1 be an exponential random variable with mean 1 and X_2 a gamma random variable with mean 2 and variance 2. If X_1 and X_2 are independently distributed, then $P(X_1 < X_2)$ is equal to _____

10.6 Let $X_1, X_2, X_3, \ldots$ be a sequence of i.i.d. uniform $(0, 1)$ random variables. Then, the value of

$$\lim_{n \to \infty} P(-\ln(1 - X_1) - \ldots - \ln(1 - X_n) \geq n)$$

is equal to _____

10.7 Let X be a standard normal random variable. Then, $P(X < 0 | \, |[X]| = 1)$ is equal to

(a) $\frac{\Phi(1) - \frac{1}{2}}{\Phi(2) - \frac{1}{2}}$

(b) $\frac{\Phi(1) + \frac{1}{2}}{\Phi(2) + \frac{1}{2}}$

(c) $\frac{\Phi(1) - \frac{1}{2}}{\Phi(2) + \frac{1}{2}}$

(d) $\frac{\Phi(1)+1}{\Phi(2)+1}$

10.8 Let $X_1, X_2, X_3, \ldots X_n$ be a random sample from the probability density function

$$f(x) = \begin{cases} \theta\alpha e^{-\alpha x} + (1-\theta)\, 2\alpha e^{-2\alpha x}; & \text{if } x \geq 0 \\ 0 & \text{otherwise,} \end{cases}$$

where $\alpha > 0,\ 0 \leq \theta \leq 1$ are parameters. Consider the following testing problem: $H_0 : \theta = 1, \alpha = 1$ versus $H_1 : \theta = 0, \alpha = 2$.

(a) Uniformly Most Powerful test does NOT exist

(b) Uniformly Most Powerful test is of the form $\sum_{i=1}^{n} X_i > c$, for some $0 < c < \infty$

(c) Uniformly Most Powerful test is of the form $\sum_{i=1}^{n} X_i < c$, for some $0 < c < \infty$

(d) Uniformly Most Powerful test is of the form $c_1 < \sum_{i=1}^{n} X_i < c_2$, for some $0 < c_1 < c_2 < \infty$

10.9 Let $X_1, X_2, X_3, \ldots$ be a sequence of i.i.d. $N(\mu, 1)$ random variables. Then,

$$\lim_{n\to\infty} \frac{\sqrt{\pi}}{2n} \sum_{i=1}^{n} E\left(|X_i - \mu|\right)$$

is equal to _____

10.10 Let $X_1, X_2, X_3, \ldots, X_n$ be a random sample from uniform $[1, \theta]$, for some $\theta > 1$. If $X_{(n)}$=Maximum $(X_1, X_2, X_3, \ldots, X_n)$, then the UMVUE of θ is

(a) $\frac{n+1}{n} X_{(n)} + \frac{1}{n}$

(b) $\frac{n+1}{n} X_{(n)} - \frac{1}{n}$

(c) $\frac{n}{n+1} X_{(n)} + \frac{1}{n}$

(d) $\frac{n}{n+1}X_{(n)} + \frac{n+1}{n}$

10.11 Let $x_1 = x_2 = x_3 = 1,\ x_4 = x_5 = x_6 = 2$ be a random sample from a Poisson random variable with mean θ, where $\theta \in \{1, 2\}$. Then, the maximum likelihood estimator of θ is equal to _____

10.12 The remainder when 98! is divided by 101 is equal to _____

10.13 Let G be a group whose presentation is

$$G = \{x, y \mid x^5 = y^2 = e,\ x^2y = yx\}$$

Then G is isomorphic to

(a) $\mathbb{Z}_5$

(b) $\mathbb{Z}_{10}$

(c) $\mathbb{Z}_2$

(d) $\mathbb{Z}_{30}$

Chapter 11

2017

XE

11.1 The stream function (Ψ) of a velocity field at any location (x, y) is given as, $\Psi = xy^2 - 2x^2y^2$. What is the rate of rotation of a fluid element located at ($x = 2, y = 2$)?

(a) 8

(b) 10

(c) 12

(d) 14

11.2 The nature of velocity profile within the laminar viscous sublayer in a turbulent pipe flow is

(a) linear

(b) parabolic

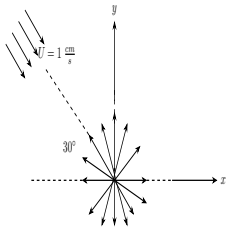
(c) logarithmic

(d) exponential

11.3 In a 5 m deep vertical cylindrical tank, water is filled up to a level of 3 m from the bottom and the remaining space is filled with oil of specific gravity 0.88. Assume

density of water as 1000 $\frac{kg}{m^3}$ and acceleration due to gravity to be 10 $\frac{m}{s^2}$. The gauge pressure $\left(\text{in } \frac{kN}{m^2}, \text{rounded off to the first decimal place}\right)$ at a depth of 2.5 m from the top of the tank will be _____.

11.4 In a two-dimensional potential flow, a point source is located at the origin ($x = 0,\ y = 0$) as shown in the figure. The strength of the point source is 2 $\frac{cm^2}{s}$. A uniform flow with velocity $1\frac{cm}{s}$ is approaching towards the point source at an angle of 30° from the horizontal axis. What is the distance (cm) of the stagnation point in the flow field from the point source?



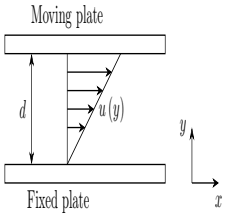
(a) $\frac{1}{\pi}$

(b) $\frac{2}{\pi}$

(c) $\frac{1}{2\pi}$

(d) $\frac{\sqrt{3}}{2\pi}$

11.5 Two infinite parallel horizontal plates are separated by a small gap ($d = 20\ mm$) as shown in figure. The bottom plate is fixed and the gap between the plates is filled with oil having density of 890 $\frac{kg}{m^3}$ and kinematic viscosity of $0.00033\frac{m^2}{s}$. A shear flow is induced by moving the upper plate with a velocity of $5\frac{m}{s}$. Assume, linear velocity profile between and the plates and the oil to be a Newtonian fluid. The shear stress $\left(\frac{N}{m^2}\right)$ at the upper plate is _____



11.6 A spherical balloon of diameter 15 m is supposed to lift a load of 3000 N. The lifting of load is achieved by heating the air inside the balloon. Assume, air to be an ideal gas and the atmospheric pressure either outside or inside the balloon. The value of acceleration due to gravity is 9.81 $\frac{m}{s^2}$ and the values of temperature and density of atmospheric air are $15°C$ and 1.2 $\frac{kg}{m^3}$, respectively. In order to lift the specified load, the air inside the balloon should be heated to a temperature ($°C$) of _____

11.7 The velocity field in Cartesian coordinate system for a two-dimensional steady flow is given as :

$$\overrightarrow{V} = \left(\frac{V_o}{L}\right)\left(x\hat{i} - y\hat{j}\right)$$

where, V_o and L are constants. Which one of the following expressions represents the acceleration field ($\overrightarrow{a}$) for this flow?

(a) $\dot{a} = 0$

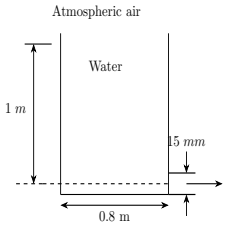
(b) $\overrightarrow{a} = \left(\frac{V_o}{L}\right)\left(x\,\hat{i} + y\,\hat{j}\right)$

(c) $\dot{a} = \left(\frac{V_o^2}{L^2}\right)\left(x\,\hat{i} - y\,\hat{j}\right)$

(d) $\dot{a} = \left(\frac{V_o^2}{L^2}\right)\left(x\,\hat{i} + y\,\hat{j}\right)$

11.8 A cylindrical tank of 0.8 m diameter is completely filled with water and its top surface is open to atmosphere as shown in the figure. Water is being discharged to the atmosphere from a circular hole of 15 mm diameter located at the bottom of the tank. The

value of acceleration due to gravity is 9.81 $\frac{m}{s^2}$. How much time (in seconds) would be required for the water level to drop from a height of 1 m to 0.5 m ?



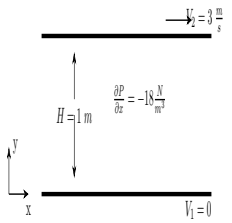
(a) 188

(b) 266

(c) 376

(d) 642

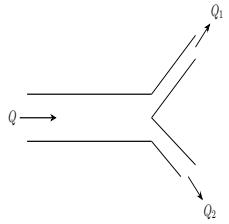
11.9 Consider steady laminar flow of an incompressible Newtonian fluid between two infinite parallel plates, separated by a distance of 1 m, as shown in the figure. The bottom plate is stationary but the top one is moving in positive x-direction with a velocity of $3\frac{m}{s}$. The fluid pressure gradient in the flow direction is : $\frac{\partial P}{\partial x} = -18\ \frac{N}{m^3}$. If the viscosity of the fluid is 1 $kgm^{-1}s^{-1}$ then the distance of the point of maximum velocity (in meters, rounded off to the second decimal place) from the bottom plate would be _____



11.10 An inviscid incompressible fluid of density 1000 $\frac{kg}{m^3}$ is flowing in a horizontal pipe of tapered cross-section with a flow rate of 4000 $\frac{cm^3}{s}$. The area of cross-section at two

different location 'A' and 'B' are 10 cm^2 and 20 cm^2, respectively. The velocity of the fluid at the location 'A' is $4\frac{m}{s}$ and the pressure is $5\frac{N}{m^2}$. The pressure $\left(\frac{N}{m^2}\right)$ at the location 'B' would be _____

11.11 A viscous, incompressible and Newtonian fluid flowing through the main branch of a circular pipe bifurcates into two daughter branches whose radii are 4 cm and 2 cm, respectively. The flow in both the daughter branches are laminar and fully developed. If the pressure gradients in both the daughter branches are same, then fraction of total volumetric flow rate (rounded off to the second decimal place) coming out from the branch with 4 cm diameter is _____



11.12 The volumetric flow rate (Q) of a triangular notch is a function of the upstream liquid surface elevation (H) measured form the bottom of the notch, acceleration due to gravity (g), notch angle (ϕ) and the approach velocity (V). Which one of the following is the correct expression for Q ?

(a) $Q = H^{\frac{1}{2}} f\left(\frac{V}{\sqrt{H}}, \phi\sqrt{g}\right)$

(b) $Q = H f\left(\frac{V}{\sqrt{H}}, \phi\sqrt{g}\right)$

(c) $Q = H^{\frac{3}{2}} f\left(\frac{V}{\sqrt{H}}, \phi\sqrt{g}\right)$

(d) $Q = H^{\frac{5}{2}} f\left(\frac{V}{\sqrt{H}}, \phi\sqrt{g}\right)$

11.13 Model tests are to be carried out to study the flow through a large prototype value of 0.6 m diameter at a flow rate of 10 $\frac{m^3}{s}$. The same working fluid is used for both the

model and the prototype. A complete geometric similarity is maintained between the model and the prototype. If the valve diameter of the model is 80 mm, its required flow rate $\left(\text{in } \frac{m^3}{s}, \text{ rounded off to the first decimal place}\right)$ would be _____

EE

11.1 The matrix $\mathbf{A}=\begin{bmatrix} \frac{3}{2} & 0 & \frac{1}{2} \\ 0 & -1 & 0 \\ \frac{1}{2} & 0 & \frac{3}{2} \end{bmatrix}$ has three distinct eigenvalues and one of its eigenvectors is $\begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix}$. Which one of the following can be another eigenvector of $\mathbf{A}$?

(a) $\begin{bmatrix} 0 \\ 0 \\ -1 \end{bmatrix}$

(b) $\begin{bmatrix} -1 \\ 0 \\ 0 \end{bmatrix}$

(c) $\begin{bmatrix} 1 \\ 0 \\ -1 \end{bmatrix}$

(d) $\begin{bmatrix} 1 \\ -1 \\ 1 \end{bmatrix}$

11.2 For a complex number z, $\lim_{z \to i} \frac{z^2+1}{z^3+2z-1(z^2+2)}$ is

(a) $-2i$

(b) $-i$

(c) i

(d) $2i$

11.3 Let $z(t) = x(t) * y(t)$ where "*" denotes convolution. Let c be a positive real-valued constant. Choose the correct expression for $z(ct)$.

(a) $c \cdot x(ct) * y(ct)$

(b) $x(ct) * y(ct)$

(c) $c \cdot x(t) * y(ct)$

(d) $c \cdot x(ct) * y(t)$

11.4 A solid iron cylinder is placed in a region containing a uniform magnetic field such that the cylinder axis is parallel to the magnetic field direction. The magnetic field lines inside the cylinder will

(a) bend closer to the cylinder

(b) bend farther away from the axis

(c) remain uniform as before

(d) cease to exist inside the cylinder

11.5 Consider an electron, a neutron and a proton initially at rest and placed along a straight line such that the neutron is exactly at the center of the line joining the electron and proton. At $t = 0$, the particles are released but are constrained to move along the same straight line. Which of these will collide first?

(a) the particles will never collide

(b) all will collide together

(c) proton and neutron

(d) electron and neutron

11.6 The transfer function of a system is given by.

$$\frac{V_o(s)}{V_i(s)} = \frac{1-s}{1+s}$$

Let the output of the system be $v_o(t) = V_m \sin(\omega t + \phi)$ for the input, $v_i(t) = V_m \sin(\omega t)$. Then the minimum and maximum values of ϕ (in radius) are respectively

(a) $\frac{-\pi}{2}$ and $\frac{\pi}{2}$

(b) $\frac{-\pi}{2}$ and 0

(c) 0 and $\frac{\pi}{2}$

(d) $-\pi$ and 0

11.7 Consider the system with following input-output relation

$$y[n] = (1 + (-1)^n)\, x[n]$$

where, $x[n]$ is the input and $y[n]$ is the output. The system is

(a) invertible and time invariant

(b) invertible and time varying

(c) non-invertible and time invariant

(d) non-invertible and time varying

11.8 A 4 pole induction machine is working as an induction generator. The generator supply frequency is 60 Hz. The rotor current frequency is 5 Hz. The mechanical speed of the rotor in RPM is

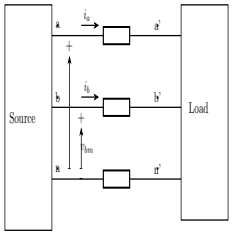
(a) 1350

(b) 1650

(c) 1950

(d) 2250

11.9 A source is supplying a load through a 2-phase, 3-wire transmission system as shown in the figure below. The instantaneous voltage and current in phase are $v_{an} = 220\sin(100\pi t)\ V$ and $i_a = 10\sin(100\pi t)\ A$, respectively. Similarly for phase-b, the instantaneous voltage and current are $v_{bn} = 220\cos(100\pi t)\ V$ and $i_b = 10\cos(100\pi t)\ A$, respectively.



(a) 2200 W

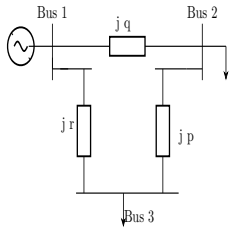
(b) $2200\sin^2(100\pi t)\ W$

(c) 4400 W

(d) $2200\sin(100\pi t)\cos(100\pi t)\ W$

11.10 A 3-bus power system is shown in the figure below, where the diagonal element of Y-bus matrix are:$Y_{11} = -j12\ pu$, $Y_{22} = -j\ pu$ and $Y_{33} = -j7\ pu$.

The per unit values of the line reactances p, q and r shown in the figure are



(a) $p = -0.2,\ q = -0.1,\ r = -0.5$

(b) $p = 0.2,\ q = 0.1,\ r = 0.5$

(c) $p = -5, ; q = -10,\ r = -2$

(d) $p = 5,\ q = 10,\ r = 2$

11.11 A closed loop system has the characteristic equation given by $s^3 + Ks^2 + (K+2)\,s + 3 = 0$. For this system to be stable, which one of the following conditions should be satisfied?

(a) $0 < K < 0.5$

(b) $0.5 < K < 1$

(c) $0 < K < 1$

(d) $K > 1$

11.12 The slope and level detector circuit in a CRO has a delay of 100 ns. The start-stop sweep generator has a response time of 50 ns. In order to display correctly, a delay line of

(a) 150 ns has to be inserted into the y-channel

(b) 150 ns has to be inserted into the x-channel

(c) 150 ns has to be inserted into both x and y channels

(d) 100 ns has to be inserted into both x and y channels

11.13 The Boolean expression $AB + A\bar{C} + BC$ simplifies to

(a) $BC + A\bar{C}$

(b) $AB + A\bar{C} + B$

(c) $AB + A\bar{C}$

(d) $AB + BC$

Chapter 12

2018

Chapter 13

2019

Chapter 14

2020

PH

14.1 Let u^{μ} denote the 4-velocity of a relativistic particle whose square $u^{mu}u_{mu} = 1$. If $\epsilon_{\mu\nu\rho\sigma}$ is the Levi-Civita tensor then the value of $\epsilon_{\mu\nu\rho\sigma}u^{\mu}u^{v}u^{\rho}u^{\sigma}$ is _____.

14.2 Consider a simple cubic monoatomic Bravais lattice which has a basis with vectors $\overrightarrow{r_1} = 0, \overrightarrow{r_2} = \frac{a}{4}(\hat{x} + \hat{y} + \hat{z})$, a is the lattice parameter. The Bragg reflection is observed due to the change in the wave vector between the incident and the scatterd beami is given by $\overrightarrow{K} = n_1\overrightarrow{G_1} + n_2\overrightarrow{G_2} + n_3\overrightarrow{G_3}$, where $\overrightarrow{G_1}$,$\overrightarrow{G_2}$ and $\overrightarrow{G_3}$ are primitive reciprocal lattice vectors. For $n_1 = 3,\ n_2 = 3$ and $n_3 = 2$, the geometrical structure factor is _____.

14.3 A plane electromagnetic wave of wavelength λ is incident on a circular loop of conducting wore. The loop radius is $a\,(a << \lambda)$. THe angle (in degrees), made by the Poynting vector with the normal to the plane of the loop to generate a maximum induced electrical signal, is _____.

14.4 An electron in a hydrogen atom is in the state $n = 3,\ l = 2,\ m = -2$. Let $\hat{L_y}$ denote the y-component of the orbital angular momentum operator. If $\left(\Delta\hat{L_y}\right)^2 = \alpha\hbar^2$, the value of α is _____.

14.5 A sinusoidal voltage of the form $v(t) = V_o \cos(\omega t)$ is applied across a parallel plate capacitor placed in vacuum. Ignoring the edge effects, the induced emf within the region between the capacitor plates can be expressed as a power series in ω. The lowest non-vanishing exponent in ω is _____.

14.6 If $\sum_{k=1}^{\infty} a_k \sin(kx)$, for $-\pi \leq x \leq \pi$, the value of a_2 is _____.

14.7 Let $f_n(x) = \begin{cases} 0, & \text{if } x < -\frac{1}{2n} \\ n, & \text{if } -\frac{1}{2n} < x < \frac{1}{2n} \\ 0, & \text{if } x > \frac{1}{2n} \end{cases}$

The value of $\lim_{n\to\infty} \int_{-\infty}^{\infty} f_n(x) \sin x dx$ is _____.

14.8 Consider the Hamiltonian $\hat{H} = \hat{H}_0 + \hat{H}'$ where

$\hat{H}_0 = \begin{pmatrix} E & 0 & 0 \\ 0 & E & 0 \\ 0 & 0 & E \end{pmatrix}$ and $\hat{H}'$ is the time independent pertubation given by

$\hat{H}' = \begin{pmatrix} 0 & k & 0 \\ k & 0 & k \\ 0 & k & 0 \end{pmatrix}$, where $k > 0$. If, the maximum energy eigenvalue of $\hat{H}$ is 3 eV corresponding to $E = 2$ eV, the value of k (rounded off to three decimal places) in eV is _____.

14.9 A hydrogen atom is in orbital angular momentum $|l, m = l\rangle$. If $\overrightarrow{L}$ lies on a cone which makes a half angle 30°with respect to z-axis, the value of l is _____.

14.10 In the center of mass frame, two protons having energy 7000 GeV, collide to produce protons and anti-protons. The maximum number of anti-protons produced is _____.

(Assume the proton mass to be 1 $\frac{GeV}{c^2}$)

14.11 Consider a gas of hydrogen atoms in the atmosphere of the Sun where the temperature is 5800 K. If a sample from this atmosphere contains 6.023×10^{23} of hydrogen atoms in the ground state, the number of hydrogen atoms in the first excited state is approximately 8×10^n, where n is an integer. The value of n is _____.
$\left(\text{Boltzmann constant: } 8.617 \times 10^{-5} \frac{eV}{K}\right)$

14.12 For a gas of non-interacting particles, the probability that a particle has a speed v in the interval v to $v + dv$ is given by

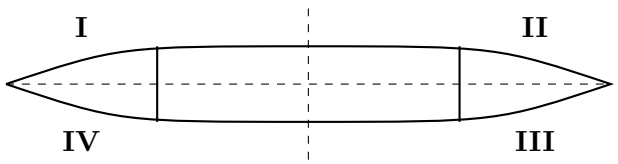
$$f(v)\,dv = 4\pi v^2 dv \left(\frac{m}{2\pi k_B T}\right)^{\frac{3}{2}} e^{\frac{mv^2}{2k_B T}}$$

If E is the energy of a particle, then the maximum in the corresponding energy distributions in units of $\frac{E}{k_B T}$ occurs at _____ (rounded off to one decimal place).

14.13 The Planck's energy density distribution in given by $u(\omega) = \frac{\hbar\omega^3}{\pi^2 c^3 \left(e^{\frac{\hbar\omega}{k_B T}} - 1\right)}$. At long wavelengths, the energy density of photons in thermal equilibrium with a cavity at temperature T varies as T^α, where α is _____.

AE

14.1 The positive high angle-of-attack condition is obtained in a steady pull-out maneuver at the largest permissible angle-of-attack of the wing. Under this condition, at which of the following regions of the wing does the maximum tension occur?



(a) I

(b) II

(c) III

(d) IV

14.2 The natural frequency of the first mode of a rectangular cross section cantilever aluminum beam is $\omega \frac{rad}{s}$. If the material and cross-section remain the same, but the length of the beam is doubled, the first mode frequency will become

(a) $\frac{\omega}{4} \frac{rad}{s}$

(b) $4\omega \frac{rad}{s}$

(c) $\frac{\omega}{16} \frac{rad}{s}$

(d) $16\omega \frac{rad}{s}$

14.3 Given $A = \begin{pmatrix} \sin\theta & \tan\theta \\ 0 & \cos\theta \end{pmatrix}$, the sum of squares of eigenvalues of A is

(a) $\tan^2\theta$

(b) 1

(c) $\sin^2\theta$

(d) $\cos^2\theta$

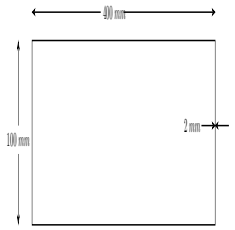
14.4 Burnout velocity of a space vehicle in a circular orbit at angle 5 degrees above the local horizon around earth is 13.5 $\frac{km}{s}$. Tangential velocity of the space vehicle in the orbit is _____ $\frac{km}{s}$ (*round off to two decimal places*).

14.5 Velocity of an airplane in the body fixed axes is given as $[100 \ -10 \ 20] \frac{m}{s}$. The sideslip angle is _____ degrees (*round off to two decimal places*).

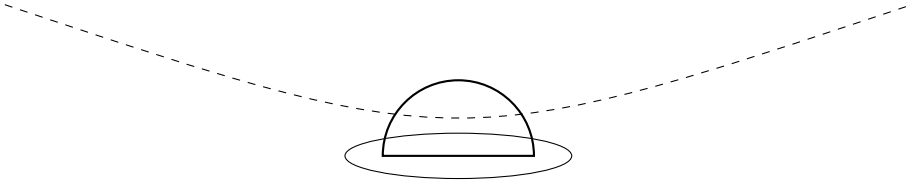
14.6 The similarity solution for the diffusion equation, $\frac{\partial u}{\partial t} = \alpha \frac{\partial^2 u}{\partial x^2}$ is $u(x,\ t) = u(\eta)$, where similarity variable, $\eta = \frac{x}{\sqrt{\alpha t}}$. If $u(x\ 0) = e^{-x^2}$, the ratio $\frac{u(0,\ 1)}{u(0\ 4)} =$ _____ (*round off to one decimal place*).

14.7 Air enters the rotor of an axial compressor stage with no pre-whirl ($C_\theta = 0$) and exits the rotor with whirl velocity, $C_\theta = 150\frac{m}{s}$. The velocity of rotor vanes, U is $200\frac{m}{s}$. Assume $C_P = 100\frac{J}{kg\ K}$, the stagnation temperature rise across the rotor is _____ K (*round off to one decimal place*).

14.8 A thin walled beam of constant thickness shown in the figure is subjected to a torque of 3.2 kNm. If the shear modulus is $25GPa$, the angle of twist per unit length is _____ $\frac{rad}{m}$ (*round off to three decimals*).



14.9 An airplane of mass 5000 kg is flying at a constant speed of 360 $\frac{km}{h}$ at the bottom of a vertical circle with a radius of 400 m, as shown in the figure. Assuming that the acceleration due to gravity is 9.8 $\frac{m}{s^2}$, the load factor experienced at the center of gravity of the airplane is _____ (*round off to two decimal places*).



Airplane

14.10 The equation $x\frac{dx}{dy} + y = c$, where c is a constant, represents a family of

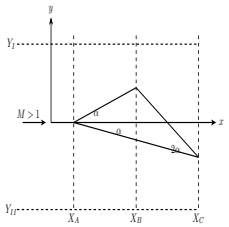
(a) exponential curves

(b) parabolas

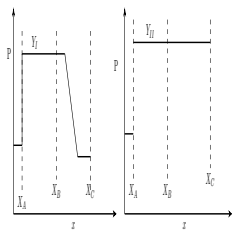
(c) circles

(d) hyperbolas

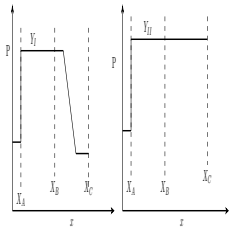
14.11 A wedge shaped airfoil is placed in a supersonic flow as shown in figure (not to scale). The corners of the wedge are at $x = \mathrm{x}_A$, $x = \mathrm{x}_B$, $x = \mathrm{x}_C$, respectively.



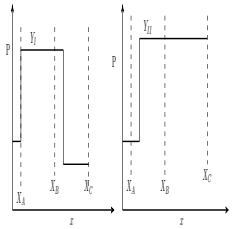
Which one of the following represents the correct static pressure along $y = \mathrm{Y}_I$ and $y = \mathrm{Y}_{II}$?



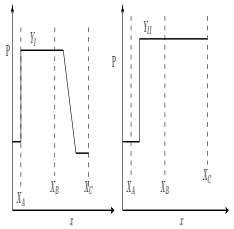
(a)



(b)



(c)



(d)

14.12 The value of Poisson's ratio at which the shear modulus of an isotropic material is equal to the bulk modulus is

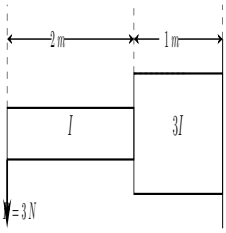
(a) $\frac{1}{2}$

(b) $\frac{1}{4}$

(c) $\frac{1}{6}$

(d) $\frac{1}{8}$

14.13 A load P is applied to the free end of a stepped cantilever beam as shown in the figure. The Young's modulus of the material is E, and the moments of inertia of the two sections of length 2 m and 1 m are I and $3I$, respectively. Ignoring transverse shear and stress concentration effects, the deflection at the point where the load is applied at the free end of the cantilever is



(a) $\frac{23}{243EI}$

(b) $\frac{1}{3EI}$

(c) $\frac{43}{3EI}$

(d) $\frac{23}{3EI}$

Chapter 15

2021

ST

15.1 The current population of a city is $11,02,500$. If it has been increasing at the rate of 5% per annum, what was its population 2 years ago ?

(a) $9,92,500$

(b) $9,95,006$

(c) $10,00,000$

(d) $12,51,506$

15.2 p and q are positive integers and $\frac{p}{q} + \frac{q}{p} = 3$, then, $\frac{p^2}{q^2} + \frac{q^2}{p^2} =$

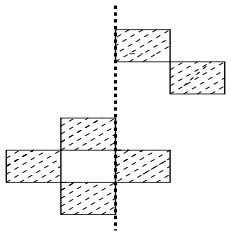
(a) 3

(b) 7

(c) 9

(d) 11

15.3 The least number of squares that must be added so that the line P-Q becomes the lines of symmetry is _____.



(a) 4

(b) 3

(c) 6

(d) 7

15.4 *Nostalgia* is to *anticipation* as _____ is to _____

Which one of the following options maintains a similar logical relation in the above sentence?

(a) Present,past

(b) Future, past

(c) Past, future

(d) Future, present

15.5 Consider the following sentences:

(**i**) I woke up from sleep.

(**ii**) I woked up from sleep.

(**iii**) I was woken up from sleep.

(**iv**) I was wokened up from sleep.

Which of the above sentences are grammatically CORRECT?

(a) (**i**) and (**ii**)

(b) (**i**) and (**iii**)

(c) (**ii**) and (**iii**)

(d) (**i**) and (**iv**)

Q.6-Q.10 Multiple Choice Questions (MCQ), carry two marks each (for each wrong answer: $-\frac{2}{3}$)

15.6 Given below are two statements and two conclusions.

Statement 1: All purple are green.

Statement 2: All black are green.

Conclusion I: Some black are purple.

Conclusion II: No black is purple.

Based on the above statements and conclusions, which one of the following options are logically CORRECT?

(a) Only conclusion I is correct.

(b) Only conclusion II is correct.

(c) Either conclusion I or II is correct.

(d) Both conclusion I and II are correct.

15.7 Computers are ubiquitous. They are used to improve efficiency in almost all fields from agriculture to space exploration. Artificial intelligence (AI) is currently a hot topic. AI enables computers to learn, give enough training data. For humans, sitting in front of computer for long hours can lead to health issues.

Which of the following can be deduced from the above passage?

(i) Nowadays, computers are present in almost all places.

(ii) Computers cannot be used for solving problems in engineering.

(iii) For humans, there are both positive and negative effects of using computers.

(iv) Artificial intelligence can be done without the data.

(a) (ii) and (iii)

(b) (ii) and (iv)

(c) (i), (iii) and (iv)

(d) (i) and (iii)

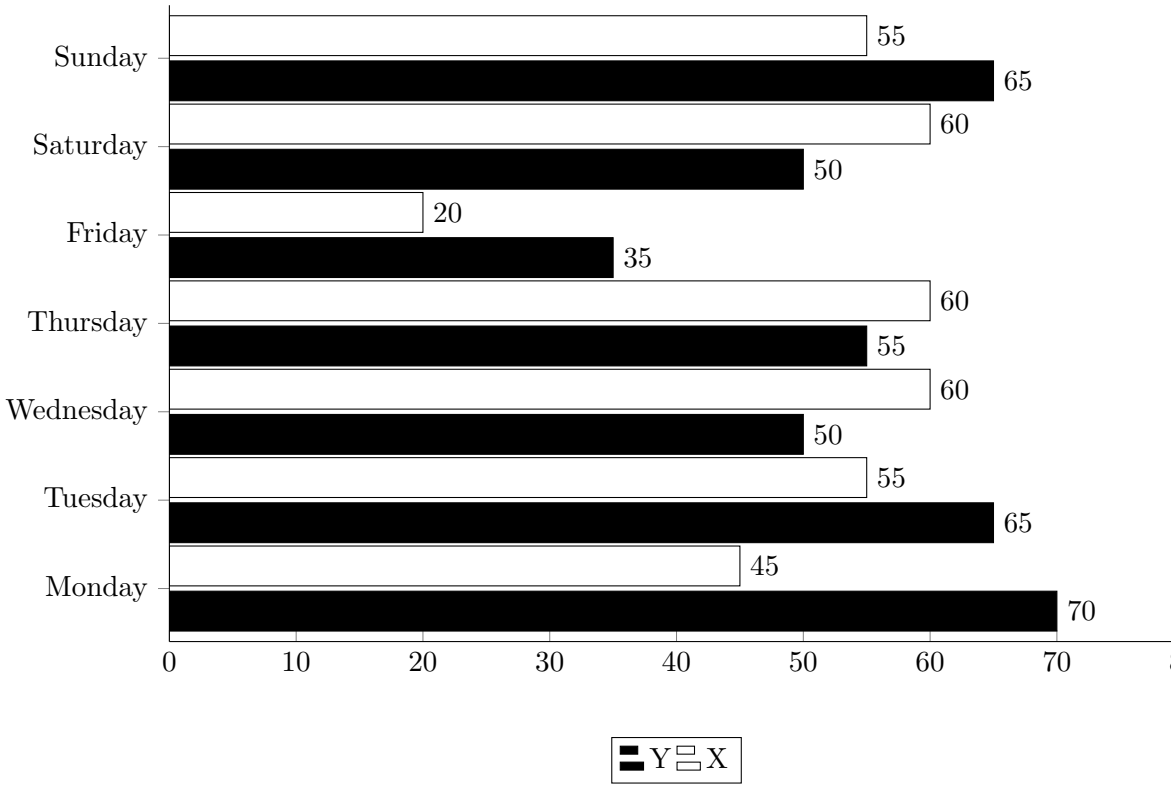
15.8 Consider a square sheet of side 1 unit. In the first step, it is cut along the main diagonal to get two triangles. In the next step, one of the cut triangles is revolved about its short edge to form a solid cone. The volume of the resulting cone, in cubic units, is _____.

(a) $\frac{\pi}{3}$

(b) $\frac{2\pi}{3}$

(c) $\frac{3\pi}{2}$

(d) 3π



15.9

The number of minutes spent by two students, **X** and **Y**, exercising every day in a given week are shown in the bar chart above.

The number of days in the given week in which one of the students spent a minimum 10% more than the other student, on a given day, is

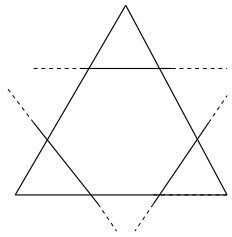
(a) 4

(b) 5

(c) 6

(d) 7

15.10 Corners are cut from an equilateral triangle to produce a regular convex hexagon as shown in the figure above.



The ratio of the area of the regular convex hexagon to the area of the original equilateral triangle is

(a) $2 : 3$

(b) $3 : 4$

(c) $4 : 5$

(d) $5 : 6$

15.11 Let X be a non-constant positive random variable such that $E(X) = 9$. Then which one of the following statements is true?

(a) $E\left(\frac{1}{X+1}\right) > 0.1$ and $P(X \geq 10) \leq 0.9$

(b) $E\left(\frac{1}{X+1}\right) < 0.1$ and $P(X \geq 10) \leq 0.9$

(c) $E\left(\frac{1}{X+1}\right) > 0.1$ and $P(X \geq 10) > 0.9$

(d) $E\left(\frac{1}{X+1}\right) < 0.1$ and $P(X \geq 10) > 0.9$

15.12 Let $\{W(t)\}_{t\geq 0}$ be a standard Brownian motion. Then the variance of $W(1)W(2)$ equals

(a) 1

(b) 2

(c) 3

(d) 4

15.13 Let $X_1, X_2, \ldots, X_n$ be a random sample of size n(≥ 2) from a distribution having the probability density function

$$f(x,\theta) = \begin{cases} \frac{1}{\theta} e^{-\frac{x-\theta}{\theta}}, & x > \theta \\ 0, & otherwise \end{cases}$$

where $\theta \in (0, \infty)$. Then the method of moments estimator of θ equals

(a) $\frac{1}{2n} \sum_{i=1}^{n} X_i$

(b) $\frac{2}{n} \sum_{i=1}^{n} X_i$

(c) $\frac{1}{n} \sum_{i=1}^{n} X_i$

(d) $\frac{n}{\sum_{i=1}^{n} X_i}$

Chapter 16

2022

Chapter 17

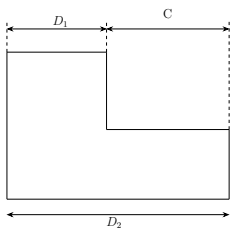
2023

ME

17.1 A part, produced in high volumes, is dimensional as shown. The machining process making this part is known to be statistically in control based on sampling data. The sampling data shows that D_1 follows a normal distribution with a mean of 20 mm and a standard deviation of 0.3 mm, while D_2 follows a normal distribution with a mean of 35 mm and a standard deviation of 0.4 mm. An inspection of dimension C is carried out in a sufficiently large number of parts.

To be considered under six-sigma process control, the upper limit of dimension C should be _____ mm.

(*Rounded off to one decimal place*)

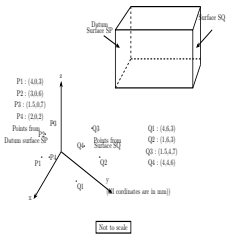


17.2 A coordinate measuring machine (CMM) is used to determine the distance between Surface SP and Surface SQ of an approximately cuboidal shaped part. Surface SP

is declared as the datum as per the engineering drawing used for manufacturing this part. The CMM is used to measure four points $P_1,\ P_2,\ P_3,\ P_4$ on surface SP, and four points $Q_1,\ Q_2,\ Q_3,\ Q_4$ on Surface SQ as shown. A regression procedure is used to fit the necessary planes.

The distance between the two fitted planes is _____ mm.

(*Answer in integer*)

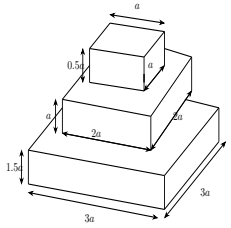


17.3 A solid part (see figure) of polymer material is to be fabricated by additive manufacturing (AM) in square-shaped layers starting from the bottom of the part working upwards. The nozzle diameter of the AM machine is $\frac{a}{10}\ mm$ and the nozzle follows a linear serpentine path parallel to the sides of the square layers with a feed rate of $\frac{a}{5}\ \frac{mm}{min}$.

Ignore any tool path motions other than those involved in adding material, and any other delays between layers or the serpentine scan lines.

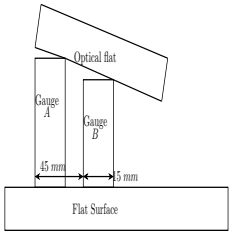
The time taken to fabricate this part is _____ minutes.

(*Answer in integer*)



17.4 An optical flat is used to measure the height difference between a reference slip gauge A and a slip gauge B. Upon viewing via the optical flat using a monochromatic light of wavelength 0.5 μm, 12 fringes were observed over a length of 15 mm of gauge B. If the gauges are placed 45 mm apart, the height difference of the gauge is _____. μm.

(*Answer in integer*)

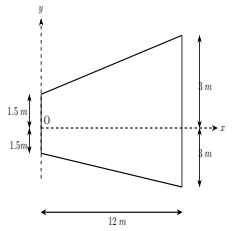


17.5 Ignoring the small elastic region, the true stress (σ)- true strain (ϵ) variation of a material beyond yielding follows the equation $\sigma = 400\epsilon^{0.3}\ MPa$. The engineering ultimate tensile strength value of this material is _____ MPa.

(*Rounded off to one decimal place*)

17.6 The area moment of inertia about y-axis of a linearly tapered section shown in the figure is _____ m^4.

(*Answer in integer*)

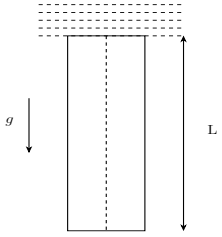


17.7 A cylindrical bar has a length $L = 5\ m$ and cross section are $S = 10\ m^2$. The bar is made of a linear elastic material with a density $\rho = 2700\frac{kg}{m^3}$ and Young's modulus

$E = 70\ GPa$. The bar is suspended as shown in the figure and is in a state of uniaxial tension due to its self-weight.

The elastic strain energy stored in the bars equals _____ J.(*Rounded off to two decimal places*)

Take the acceleration due to gravity as $g = 9.8\ \frac{m}{s^2}$.



17.8 A cylinder transmission shaft of length 1.5 m and diameter 100 mm is made of a linear elastic material with a shear modulus 80 GPa. While operating at 500 rpm, the angle of twist across its length is found to be 0.5 degrees.

The power transmitted by the shaft at this speed is _____ kW. (*Rounded off to two decimal places*)

Take $\pi = 3.14$.

17.9 Consider a mixture of two ideal gases, X and Y, with molar masses $\bar{M}_X = 10\ \frac{kg}{kmol}$ and $\bar{M}_Y = 20\ \frac{kg}{kmol}$, respectively, in a container. The total pressure in the container is 100 kPa, the total volume if the container is 10 m^3 and the temperature of the contents of the container is 300 K. If the mass of gas-X in the container is 2 kg, then the mass of the gas-Y in the container is _____kg.(*Rounded off to one decimal place*)

Assume that the universal gas constant is 8314 $J\ kmol^{-1}K^{-1}$.

17.10 The velocity field of a certain two-dimensional flow is given by

$$\mathbf{V}(x, y) = k\left(x\hat{i} - y\hat{j}\right)$$

where $k = 2\ s^{-1}$. The coordinates x and y are in meters. Assume gravitational effects to be negligible.

If the density of the fluid is $1000\frac{kg}{m^3}$ and the pressure at the origin is 100 kPa, the pressure at the location $(2\ m,\ 2\ m)$ is _____ kPa.

(*Answer in integer*)

17.11 Consider a unidirectional fluid flow with the velocity field given by

$$\mathbf{V}(x, y, z, t) = u(x, t)\ \hat{i}$$

where $u(0, t) = 1$. If the spatially homogeneous density field varies with time t as

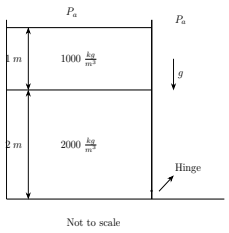
$$\rho(t) = 1 + 0.2e^{-t}$$

the value of $u(2, 1)$ is _____.(*Rounded off to two decimal places*)

Assume all quantities to be dimensionless.

17.12 The figure shows two fluids held by a hinged gate. The atmospheric pressure is $P_a = 100\ kPa$. The moment per unit width about the base of the hing is _____ $\frac{kNm}{m}$.(*Rounded off to one decimal place*)

Take the acceleration due to gravity to be $g = 9.8\frac{m}{s^2}$.

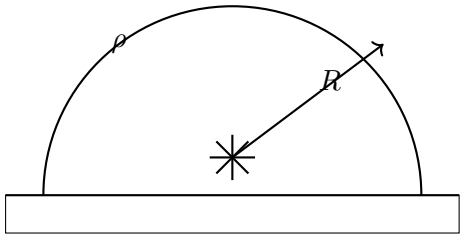


17.13 An explosion at time $t = 0$ releases energy E at the origin in a space filled with a gas

of density ρ. Subsequently, a hemispherical blast wave propagates radially outwards as shown in the figure.

Let R denote the radius of the hemisphere blast wave. The radius R follows the relationship $R = kt^a E^b \rho^c$, where k is a dimensionless constant. The value of exponent a is _____.

(*Rounded off to one decimal place*)



Chapter 18

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