MADE EASY

GATE 2026

Mechanical Engineering

Afternoon Session

Detailed Solutions

Exam held on 14-02-2026

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SECTION - A GENERAL APTITUDE

1. 'The team ______ more than 300 runs in 20 overs ___________ rains. However, some players needed to improve their batting skills.'
Choose the option with the correct sequence of words to fill the blanks.
(a) score; despite
(b) scoring; instead of
(c) scored; despite
(d) scoring; in spite of

Ans. (c)
Scored, Despite

End of Solution

2. If a positive real x satisfies the following equation
$\log_2 x + \log_{\sqrt{2}} x = 48$
then the value of x is ______________
(a) 2^{16}
(b) 4^{16}
(c) 2^{14}
(d) 4^{14}

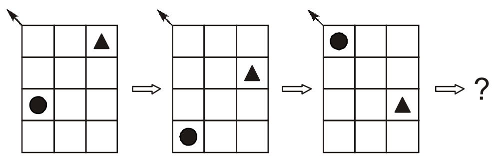
Ans. (a)

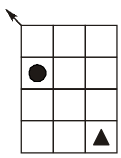
$$\log_2 x + \log_{\sqrt{2}} x = 48$$

$$\frac{\log x}{\log 2} = \frac{\log x}{\log \sqrt{2}} = \log(48) \Rightarrow x = 2^{16}$$

End of Solution

3. The next figure (indicated by '?') in the sequence is



(a)


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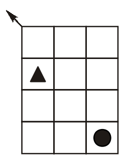

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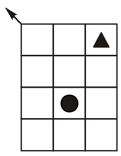

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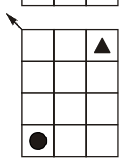


Ans. (a)
● Moving down
△ Moving down

End of Solution

4. 'All the mangoes in the basket are good.'

If the above statement is false, then which one of the following statements is necessarily true?
(a) All the mangoes in the basket are not good.
(b) No mango in the basket is good.
(c) In the basket, some of the mangoes are good and some are not good.
(d) There exists at least one mango in the basket that is not good.

Ans. (d)

End of Solution

5. Consider the following statements about four numbers:
(S1) The average of the four numbers is 25
(S2) Each number is at most 40
(S3) Each number is at least 20
Choose the option that is necessarily correct.
(a) (S1) and (S2) together imply (S3)
(b) (S2) and (S3) together imply (S1)
(c) (S1) and (S3) together imply (S2)
(d) (S1) implies (S3)

Ans. (c)

End of Solution

6. 'People are crowding around ___ pit into which ___ elephant has fallen. I have never seen an elephant looking more bewildered ___ miserable. Here it is in a most undignified position, thrust into a pit and made to look up ___ a vast, curiosity-stricken crowd.'
Choose the option with the correct sequence of words to fill the blanks.
(a) an; a; at; and
(b) a; an; and; at
(c) and; a; an; at
(d) at; a; an; and

Ans. (b)
An Elephant

End of Solution

7. The table lists the unit selling price of five products P, Q, R, S, and T. On a particular day, 250 items were sold with the average selling price of Rs. 60. The following observations were made:
(i) The quantity of S sold was twice that of T.
(ii) The quantity of R sold was thrice that of T.
(iii) The quantity of Q sold was four times that of T.

Product	P	Q	R	S	T
Unit selling price(Rs.)	100	50	40	60	60

What is the quantity of product P sold on that day?

(a) 40 (b) 50
(c) 60 (d) 70

Ans. (b)

Total item sold = 250

Average selling price = Rs. 60

Relation ships, $S = 2T$, $R = 3T$, $Q = 4T$

$P + Q + R + S + T = 250$

Let the quantity of T be x.

$P + 4x + 3x + 2x + x = 250$

$P + 10x = 250$

$P = 250 - 10x$

$100P + 50Q + 40R + 60S + 60T = 60 \times 250$

$100 (250 - 10x) + 50 (4x) + 40(3x) + 60(2x) + 60x = 15000$

$x = 20$

$P = 250 - 200 = 50$

End of Solution

8. Consider a string P of length l that is laid out as a straight-line segment. Another string K is laid out as a semicircular arc with string P as its diameter, as represented in Figure (i). When both the strings are shortened by a length x they can be re-arranged such that the shortened string K forms a full circle with the shortened string P as its diameter, as represented in Figure (ii). The value of x/l is ________

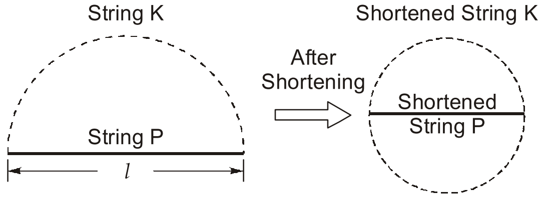


Figure (i) **Figure (ii)**

(a) π (b) $\frac{\pi - 1}{2\pi}$
(c) $\frac{\pi}{2(\pi - 1)}$ (d) $\frac{\pi}{\pi - 1}$

Ans. (c)

Length of $P = l$

Since P is the diameter, the radius, $r = \frac{l}{2}$

Length of $k = \pi r = \frac{\pi l}{2}$

Shortened lengths of $P = l - x$

Now, Length of $x = \frac{\pi l}{2} - x$

$$\frac{\pi l}{2} - x = \pi(l - x)$$

$$\frac{\pi l}{2} - x = \pi l - \pi x$$

$$\pi l - x = \frac{\pi l}{2}$$

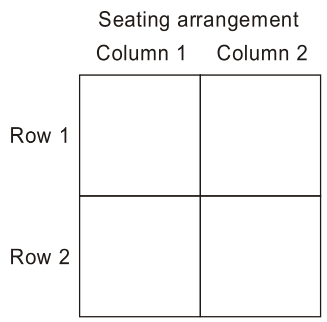
$$\frac{\pi}{l} = \frac{\pi}{2(\pi - 1)}$$

End of Solution

9. The Roman senator Meritorius, his brother, his son, and his daughter have varying oratory skill levels. They are seated in rows and columns as shown in the figure with exactly one person sitting in each box. It is known that

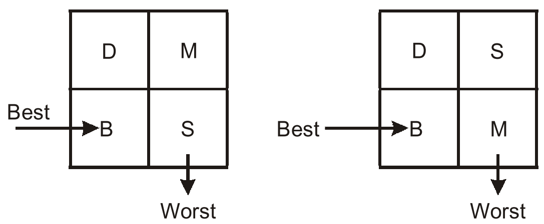
(i) Meritorius' daughter and his brother are seated in the same column.
(ii) His son is seated diagonally across the sibling of the worst orator.
(iii) The best and worst orators are seated in the same row.

Who is the best orator?



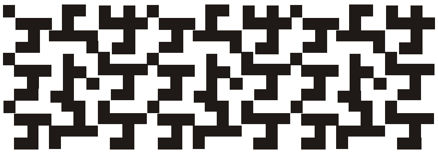
(a) Meritorius
(b) Meritorius' brother
(c) Meritorius' son
(d) Meritorius' daughter

Ans. (b)

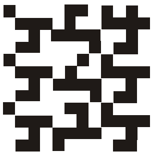


End of Solution

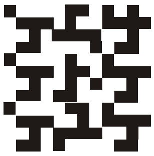
10. Which one of the patterns labelled P, Q, R, and S is used to generate the following figure?



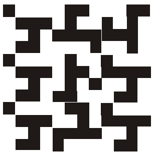
P.



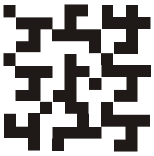
Q.



R.



R.



(a) P
(b) Q
(c) R
(d) S

Ans. (b)

End of Solution

■■■■

SECTION - B TECHNICAL

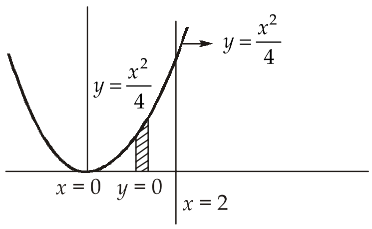
11. Domain A is bounded by curve $x^2 = 4y$, ordinate $x = 2$, and x axis.

The value of $\iint_A y\,dx\,dy$ is

(a) 1/5 (b) 1/3
(c) 5/12 (d) 1/2

Ans. (a)

Given $x^2 = 4y$,



$$\int_{x=0}^{2}\int_{y=0}^{y=\frac{x^2}{4}} y\,dy\,dx$$

$$\int_{x=0}^{x=2}\left[\frac{y^2}{2}\right]_0^{\frac{x^2}{4}} dx$$

$$\int_{x=0}^{2}\frac{x^4}{32}dx = \left[\frac{x^5}{5\times 32}\right]_0^2 = \frac{2^5}{5\times 32} = \frac{32}{5\times 32} = \frac{1}{5}$$

End of Solution

12. Let φ be a scalar function. Then $\nabla\varphi$ is

(a) always perpendicular to the surface of constant φ
(b) always parallel to the surface of constant φ
(c) the minimum rate of change of scalar φ
(d) always zero

Ans. (a)

End of Solution

13. The order and degree of the following differential equation are *m* and *n*, respectively.

$$\frac{\partial^3\varphi}{\partial x^3} + \frac{\partial^2\varphi}{\partial^2 y^2}\frac{\partial\varphi}{\partial x} + \left(\frac{\partial^2\varphi}{\partial x^2}\right)^2 + \frac{\partial\varphi}{\partial y} = 0$$

The value of $(m - n)$ is

(a) 2 (b) 3
(c) 1 (d) 0

Ans. (a)

$$\text{Degree } (n) = 1, \text{ Order } (m) = 3$$

$$\therefore \quad m - n = 3 - 1 = 2$$

End of Solution

14. Newton-Raphson method for solving algebraic equations is based on

(a) Taylor series
(b) Fourier series
(c) Laurent series
(d) Power series

Ans. (a)

End of Solution

15. The exact solution of $\int_0^4 \frac{dx}{1+x}$ is represented as n.

If m represents numerically evaluated value of the above integral using Trapezoidal rule by considering four equal subintervals in the range of x, then $(m - n)$ is

(a) 0.074
(b) –0.074
(c) –0.003
(d) 0.003

Ans. (a)

$$\int_0^4 \frac{dx}{(x+1)} = N$$

$$\int_0^4 \frac{dx}{(x+1)} dx = N$$

$$\ln(1+x)\Big|_0^4$$

$$= \ln(5) - 0$$

$$= \ln(5)$$

By trapezoidal

$$y = \frac{1}{1+x}$$

x	0	1	2	3	4
y	1	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{5}$
	y_0	y_1	y_2	y_3	y_n

$h = 1$

$$\int_0^4 \frac{1}{1+x} dx = \frac{h}{2}\left[(y_0 + y_n) + 2(y_1 + y_2 + y_3)\right]$$

$$= \frac{1}{2}\left[\left(1 + \frac{1}{5}\right) + 2 \times \left(\frac{1}{2} + \frac{1}{3} + \frac{1}{4}\right)\right]$$

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$$= \frac{1}{2}\left[\frac{6}{5} + 2 \times \frac{6+4+3}{12}\right]$$

$$= \frac{1}{2}\left[\frac{6}{5} + \frac{26}{12}\right] = 1.6823$$

$$= 1.6823 - \ln 5 = 0.074$$

End of Solution

16. A horizontal disk has a radial frictionless slot in which a small block is confined to slide. The disk turns anticlockwise about its centre with a constant angular velocity of 3 rad/s. If the block slides along the slot with a constant speed of 0.2 m/s relative to the slot, then the magnitude of Coriolis acceleration in m/s^2 is

(a) 1.2 (b) 0.6
(c) 2.4 (d) 0.3

Ans. (a)

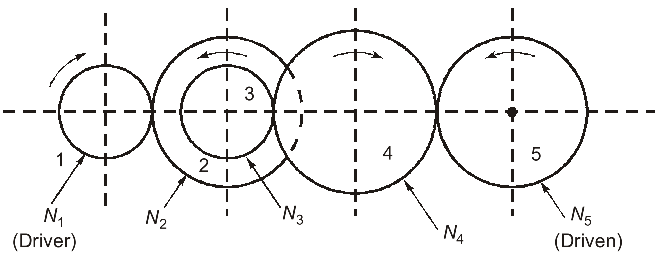
Given: $\omega = 3$ rad/s, $V_{sliding} = 0.2$ m/s

Coriolis acceleration, $a^c = 2V_{sliding}\omega$

$= 2 \times 0.2 \times 3 = 1.2$ m/s^2

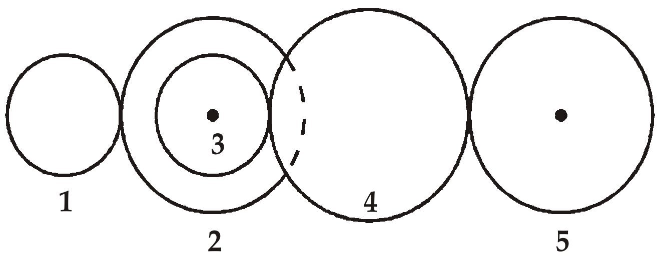
End of Solution

17. A gear train with five gears is shown in the figure below. The number of teeth on each gear is N_1, N_2, N_3, N_4, and N_5. The idler gear in this gear train is



(a) gear 4 (b) gear 2
(c) gear 3 (d) gear 1

Ans. (a)



Gear 4 is connecting left and right both.

$\Rightarrow$ Gear 4 : Idler

End of Solution

18. In a single degree of freedom vibrating system with only viscous damping, the critical damping coefficient is 350 Ns/m and the damping coefficient is 35 N s/m.
The logarithmic decrement of the vibrating system is
(a) 0.63
(b) 1.26
(c) 0.32
(d) 1.89

Ans. (a)

Given: Damping coefficient, C = 35 N/m/s
Critical damping coefficient, C_C = 350 N/m/s

We know that, $$\xi = \frac{C}{C_C} = \frac{35}{350} = 0.1$$

Logarithmic decrement, $$\delta = \frac{2\pi\xi}{\sqrt{1-\xi^2}} = \frac{2\pi \times 0.1}{\sqrt{1-(0.1)^2}} = 0.6314$$

End of Solution

19. A closely coiled helical compression spring of mean coil diameter D and wire diameter d, is loaded by an axial force F.
The maximum shear stress developed in the wire is
(a) $\frac{8FD}{\pi d^3} + \frac{4F}{\pi d^2}$
(b) $\frac{8FD}{\pi d^3} + \frac{2F}{\pi d^2}$
(c) $\frac{16FD}{\pi d^3} + \frac{4F}{\pi d^2}$
(d) $\frac{32FD}{\pi d^3} + \frac{4F}{\pi d^2}$

Ans. (a)

$$\tau_{max} = \tau_d + \tau_t$$
$$= \frac{F}{\frac{\pi}{4}d^2} + \frac{16FD/2}{\pi d^3}$$
$$= \frac{4F}{\pi d^2} + \frac{8FD}{\pi d^3}$$

End of Solution

20. The rotor of an aeroplane engine has a mass moment of inertia 1.0 kg m^2. The engine rotates at a speed of 500 RPM in the clockwise direction if viewed from the front of the aeroplane. If the aeroplane while flying at 1200 km/hr turns with a radius of 2 km at same elevation, then the magnitude of the gyroscopic moment exerted by the rotor on the aeroplane structure in N m is
(a) 8.73
(b) 17.46
(c) 4.37
(d) 26.19

Ans. (a)

Given: V = 1200 km/hr = $1200 \times \frac{5}{18} = 333.33$ m/s, I = 1 kg/m^2, R = 2 km = 2000 m.

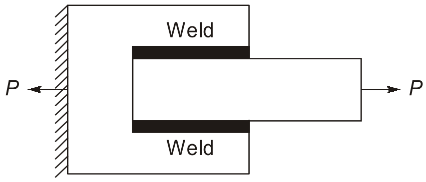
$$(\omega_p)_{turning} = \frac{V}{R} = \frac{333.33}{2000} = 0.1666 \text{ rad/s}$$

$$\omega = \frac{2\pi N}{60} = 2\pi \times \frac{500}{60} = 52.3598 \text{ rad/s}$$

$$C = I\omega\omega_p = 1 \times 52.3598 \times 0.1666 = 8.73 \text{ N-m}$$

End of Solution

21. A rectangular plate is perfectly welded to a gusset plate with parallel fillet weld joints as shown in the figure below. The length of the weld is l and the fillet weld leg size is h. The allowable shear strength of the weldment is τ_{all}. A tensile force P is applied on the plate in a direction parallel to the length of the weld. Assuming the throat of the weld as the weakest section, the critical load is



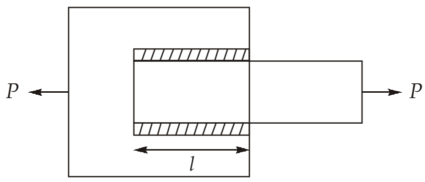
(a) $\sqrt{2}hl\tau_{all}$ (b) $hl\tau_{all}$

(c) $hl\tau_{all}/\sqrt{2}$ (d) $hl\tau_{all}/2$

Ans. (a)

Given: Length of weld $= l$, Leg size $= h$

$\therefore$ Total length of weld $= 2l$



Load, P = Area of weld × $\tau_{allowable}$

$$\text{Load, } P = \frac{h}{\sqrt{2}} \times (2l)\tau_{all},$$

$$P = \sqrt{2}hl\tau_{all}$$

End of Solution

22. Worm gearsets are used for transmitting rotary motion between

(a) non-parallel and non-intersecting shafts
(b) intersecting shafts
(c) parallel shafts
(d) non-parallel and intersecting shafts

Ans. (a)

Worm gear is used for connecting. Neither parallel nor intersecting shafts.

End of Solution

23. For an ideal gas, starting from state point 1, two different processes take place. The corresponding final states in these two processes are 2 and 3, lying on same isotherm. If P and h represent pressure and enthalpy, respectively, then which one of the following options is correct?

(a) $h_2 = h_3$
(b) $h_2 > h_3$
(c) $P_2h_3 = P_3h_2$
(d) $P_3h_3 = P_2h_2$

Ans. (a)

As, $h = C_pT$

Given $T_2 = T_3$ (2 and 3 on same isotherm)

$\therefore$ $h_2 = h_3$

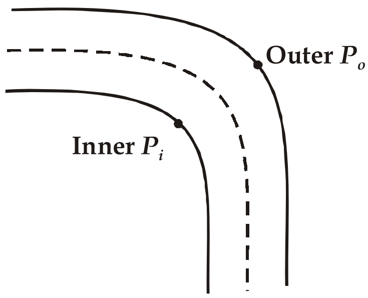
End of Solution

24. A steady incompressible laminar flow passes through a 90° tube bend placed on a horizontal surface. In horizontal diametric plane, two pressure taps P_i and P_o are provided across the cross-section at inner and outer walls of the bend, respectively. Which one of the following options is correct?

(a) $P_o > P_i$
(b) $P_o < P_i$
(c) $(P_o - P_i)$ is directly proportional to the bend radius.
(d) $(P_i - P_o)$ is inversely proportional to the average flow velocity.

Ans. (a)

Bend in horizontal plane,



Pipe bend - Free vortex,

$$V_r = C$$

$$V \propto \frac{1}{r}$$

$\therefore$ Velocity at outer side is lower and hence using Bernoulli's equation pressure is higher at outer side.

$\therefore$ $P_o > P_i$

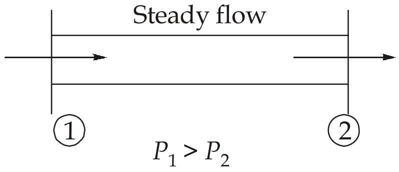
End of Solution

25. An ideal gas passes isothermally through a long horizontal uniform cross-section pipe under steady flow. Consider that the pressure gradient in the pipe is sufficient for a finite change in the density of the gas. If the flow of the gas is purely pressure driven and subsonic throughout, then the average flow velocity
(a) increases along the flow
(b) decreases along the flow
(c) does not change throughout the pipe
(d) increases in the hydrodynamic entrance region and then decreases thereafter

Ans. (a)

For steady flow,

$$\rho AV = \text{constant}$$
$$\rho . V = \text{constant}$$
$$V_2 > V_1 = (\because \rho_1 > \rho_2)$$



End of Solution

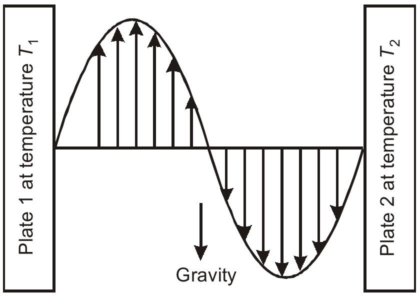
26. Bernoulli's equation CANNOT be applied between
(a) any two arbitrary points in the flow field for steady incompressible rotational flow
(b) any two arbitrary points in the flow field for steady incompressible irrotational flow
(c) any two points along a streamline for steady incompressible flow
(d) any two points along a streamline for steady incompressible rotational flow

Ans. (a)

Bernoulli's cannot be applied between two points in a rotational flow.
But along the streamline, Bernoulli's equation is applicable in rotational flow also.

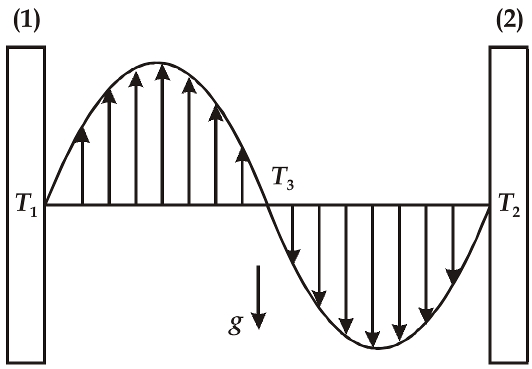
End of Solution

27. A quiescent fluid at temperature T_3 is confined between two vertical parallel plates. While plate 1 is kept at temperature T_1 and plate 2 is maintained at temperature T_2, a velocity profile between the plates, as shown in the figure below, is generated due to heat transfer. Which one of the following options shows the correct relations among T_1, T_2, and T_3?



(a) $T_1 > T_3$ and $T_3 > T_2$
(b) $T_1 > T_3$ and $T_3 < T_2$
(c) $T_1 < T_3$ and $T_3 < T_2$
(d) $T_1 < T_3$ and $T_3 > T_2$

Ans. (a)



T_3 - Temperature of fluid

$$T_1 > T_3$$
$$T_2 < T_3$$

When surface temperature is more near the surface, density of fluid near will be decreased and flow will be upward and vice-versa.

End of Solution

28. For the isothermal expansion of an ideal gas in a piston cylinder system, the net heat supplied during the process is equal to the net work. Which one of the following statements is correct for the given process?
(a) The process is possible.
(b) The process is not possible as it violates the second law of thermodynamics.
(c) The process is not possible as it violates the first law of thermodynamics.
(d) The process is possible, however, it violates the second law of thermodynamics.

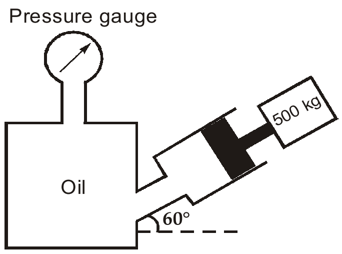
Ans. (a)

$$Q = \Delta U + W$$
$$\Delta U = 0 \text{ (for isothermal process)}$$
$$Q = W$$

Also, the process is possible.

End of Solution

29. A hydraulic crane supports a mass of 500 kg with its piston-cylinder actuator, inclined at 60° with horizontal, as shown in the figure below. The diameter of the piston is 30 cm and gravitational acceleration is 10 m/s^2. Neglecting mass of the piston, the reading of the pressure gage in kPa (gage) is



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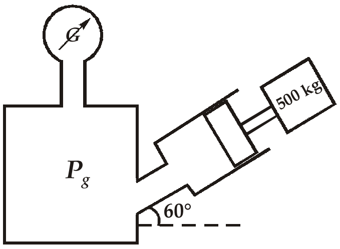
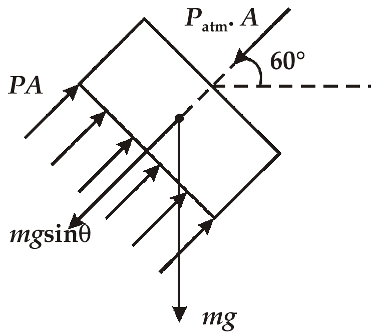
(a) 61.26 (b) 6.13
(c) 35.35 (d) 70.71

Ans. (a)

Given: m = 500 kg, d = 30 cm, g = 10 m/s^2.



FBD of piston,



$$\therefore \quad P_{gauge}A = mg\sin 60^\circ$$

$$\Rightarrow \quad P_{gauge} = \frac{500 \times 10 \times \sqrt{3} \times 4}{2 \times \pi \times 0.3^2}$$

$$\Rightarrow \quad P_{gauge} = 61.26 \text{ kPa}$$

End of Solution

30. In relation to metal casting defects, match the following

	Defect		Description
P.	Dross	1.	Shallow blow found on a flat casting surface
Q.	Scab	2.	Lighter impurities appearing on the top surface of a casting
R.	Scar	3.	A rough, thin layer of metal, protruding above the casting surface, on top of a thin layer of sand

(a) P-II, Q-III, R-I (b) P-II, Q-I, R-III
(c) P-III, Q-I, R-II (d) P-III, Q-II, R-I

Ans. (a)

End of Solution

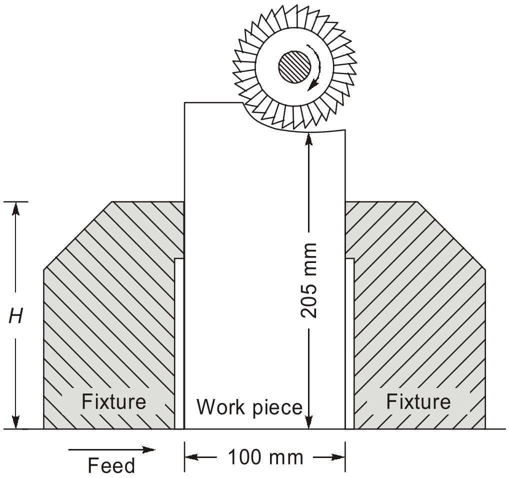
31. Which one of the following options is NOT an error associated with STereoLithography (STL) file in additive manufacturing?
(a) Staircase effect
(b) Missing facet
(c) Non-manifold topology conditions
(d) Degenerate facets

Ans. (a)

The Staircase effect is a process-related error rather than an inherent file error. It occurs due to the layer-by-layer nature of additive manufacturing, where the discrete thickness of layers creates a stepped profile on curved or sloped surfaces. While an STL file's resolution (tessellation) can influence surface finish, the "staircase" itself is a result of the slicing and physical building process.

End of Solution

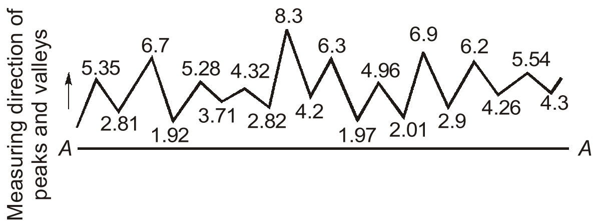
32. A work piece is to be firmly held in a fixture. It is to be machined by using a plain slab milling cutter as shown in the figure below.



Which one of the following options is the most suitable value of height H of the fixture in mm?
(a) 200
(b) 210
(c) 150
(d) 70

End of Solution

33. A two-dimensional surface profile is obtained over a sampling length by using a contact type stylus profilometer as shown in the figure below. A line AA parallel to the general lay of the trace is considered. The true heights from AA to the peaks and valleys (in μ) in the trace are also shown in the figure (not to scale).



The ten-point height average in μ is

(a) 4.57 (b) 5.99

(c) 3.09 (d) 2.90

Ans. (a)

10 point average

The value of 5 peaks = 6.7, 8.3, 6.3, 6.9, 6.2

The value of 5 valleys = 1.92, 1.97, 2.01, 2.81, 2.82

$$R_Z = \frac{\Sigma P - \Sigma V}{5} = 4.57$$

End of Solution

34. A steel plate having yield strength of 550 MPa, is subjected to biaxial state of stress as $\sigma_x = \sigma$ and $\sigma_y = -2\sigma$. Using distortion energy theory and considering the factor of safety as 2, the permissible value of s that can be applied to the plate is____ MPa (round off to 1 decimal place)

Ans. (103.94) (102.0 to 105.0)

Given data: $\sigma_1 = \sigma$, $\sigma_2 = -2\sigma$, $S_{yt} = 550$ MPa, FOS = 2

Using MDET, $$\sigma_1^2 + \sigma_2^2 - \sigma_1\sigma_2 = \left[\frac{S_{yt}}{FOS}\right]^2$$

$$\sigma^2 + (-2\sigma)^2 + 2\sigma^2 = \left(\frac{550}{2}\right)^2$$

$$\sigma = 103.94 \text{ MPa}$$

End of Solution

35. A sphere of radius 5 mm is initially in equilibrium at 400°C in a furnace. It is suddenly removed from the furnace and dipped in a well-stirred water bath at 20°C, with a convection heat transfer coefficient of 500 W/(m^2K). For the given range of temperatures, the thermophysical properties of the material of the sphere are: density ρ = 3000 kg/m^3, thermal conductivity k =10 W/(m K), and specific heat c = 1000 J/(kg K). Neglecting radiation heat transfer, the time required for the centre of the sphere to cool from 400°C to 50°C is ________ seconds (rounded off to 2 decimal places).

Ans. (25.39) (24.50 to 26.00)

Given: R = 5 mm, T_i = 400°C, T_∞ = 20°C, ρ = 3000 kg/m^3, h = 500 W/m^2°C, c_p = 1000 J/kgK, T = 50°C.

$$L_C = \frac{V}{A} = \frac{R}{3}$$

$$\because \quad \frac{T - T_\infty}{T_i - T_\infty} = e^{-\frac{ht}{\rho L_C c_p}}$$

$$\Rightarrow \quad \frac{50-20}{400-20} = e^{-\left(\frac{500\times 3}{3000\times 0.005\times 1000}\right)t}$$

$$\Rightarrow \quad t = \frac{\ln\left(\frac{30}{380}\right)}{0.1} = 25.39 \text{ sec}$$

End of Solution

36. If $w = \log_e z = \log_e (x + iy)$, where $i = \sqrt{-1}$, then which one of the following statements is correct?

(a) w is analytic everywhere except at z =0
(b) w is non-analytic everywhere
(c) The conjugate functions of w are $\log_e (x^2 + y^2)$ and $\log_e (x^2 - y^2)$
(d) The conjugate functions of w are $\tan^{-1}(x/y)$ and $\tan^{-1} (y/x)$

Ans. (a)

End of Solution

37. Consider the following differential equation

$$\frac{\partial y}{\partial x} = 3\frac{\partial y}{\partial t} + y$$

If $y(x, 0) = 10e^{-2x}$, then the solution of the differential equation is

(a) $y(x, t) = 10e^{-2x-t}$
(b) $y(x, t) = 10e^{-2x+t}$
(c) $y(x, t) = 10e^{-2x-2t}$
(d) $y(x, t) = 10e^{-2x+2t}$

Ans. (a)

$$Y = XT$$
$$Y(x, t) = X_{(x)}\, T_{(t)}$$
$$\frac{\partial y}{\partial x} = X'T, \quad \frac{\partial y}{\partial t} = XT'$$
$$X'T = 3XT' + XT$$
$$X'T = X(3T' + T)$$
$$\frac{X'}{X} = \frac{3T' + T}{T} = k(\text{Let})$$
$$X' = kX$$
$$X' - kX = 0$$

AE $\quad m - k = 0$

$$m = k$$
$$X = C_1 e^{kx}$$
$$\frac{3T' + T}{T} = k$$
$$3T' + T = kT$$
$$3T' + T - kT = 0$$
$$3T' + (1 - k)T = 0$$
$$T' + \frac{1-k}{3}T = 0$$

AE

$$m + \frac{1-k}{3} = 0$$
$$m = \frac{k-1}{3}$$
$$T = C_2 e^{\frac{k-1}{3}t}$$

Now,
$$y = C_1 e^{kx} \cdot C_2 e^{\frac{k-1}{3}t}$$
$$y = Ce^{kx} \cdot e^{\left(\frac{k-1}{3}\right)t}$$
$$y(x, t) = Ce^{kx + \frac{k-1}{3}t}$$
$$y(x, 0) = Ce^{kx} = 10e^{-2x}$$
$$C = 10, \quad k = -2$$
$$y(x, t) = 10e^{-2x-t}$$

End of Solution

38. Let $f(t)$ be a function of t defined for all positive values of t. The Laplace transform of $f(t)$ denoted by $L\{f(t)\} = \int_o^\infty e^{-st} f(t)dt$, provided that the integral exists where s is a parameter which may be a real or complex number.

The Laplace transform of $f(t) = \sin 2t \sin 4t$ is

(a) $\frac{16s}{(s^2+4)(s^2+36)}$

(b) $\frac{32s}{(s^2+4)(s^2+36)}$

(c) $\frac{16}{(s^2+4)(s^2+36)}$

(d) $\frac{32}{(s^2+4)(s^2+36)}$

Ans. (a)

$$\sin 2t \sin 4t = \frac{1}{2}[\cos(2t-4t)-\cos(2t+4t)]$$

$$= \frac{1}{2}[\cos(-2t)-\cos(6t)] = \frac{1}{2}[\cos(2t)-\cos(6t)]$$

$$L\{\sin 2t \sin 4t\} = L\left\{\frac{1}{2}[\cos 2t-\cos 6t]\right\}$$

$$= \frac{1}{2}\left[\frac{s}{s^2+4}-\frac{s}{s^2+36}\right] = \frac{16s}{(s^2+4)(s^2+36)}$$

End of Solution

---

39. A student council of 10 members consists of two students from engineering school, three students from science school and five students from arts school. The university administration selects three students from the council at random. What is the chance that out of the selected students, two belong to the same school and the third belongs to different school?

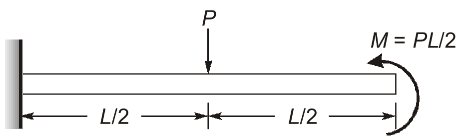
(a) 79/120 (b) 2/120
(c) 89/120 (d) 69/120

Ans. (a)

End of Solution

---

40. A cantilever beam of length L is subjected to a concentrated load P and a moment M as shown in the figure below. Neglecting the mass of the beam, which one of the following options is the correct representation of shear force diagram (SFD) and bending moment diagram (BMD)?



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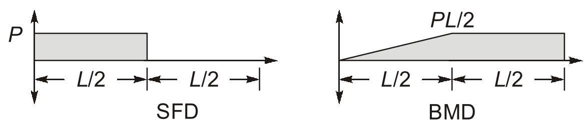

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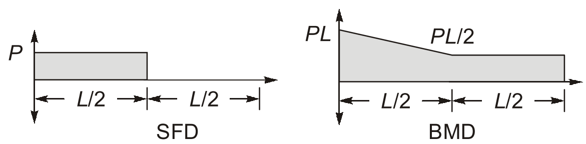

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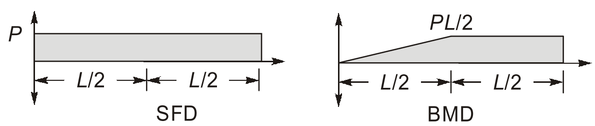

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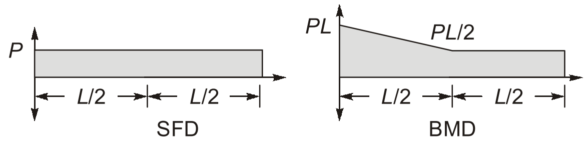
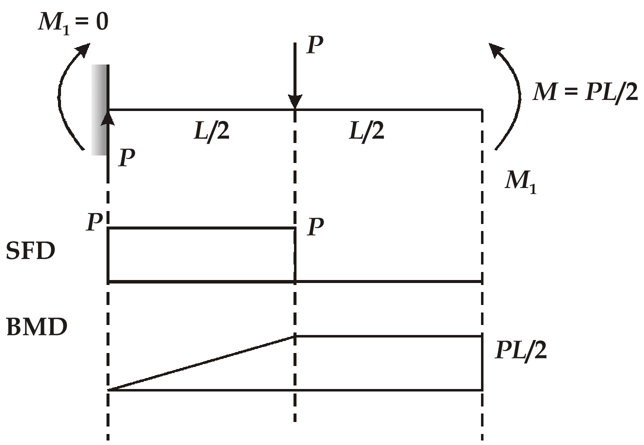
(d) 

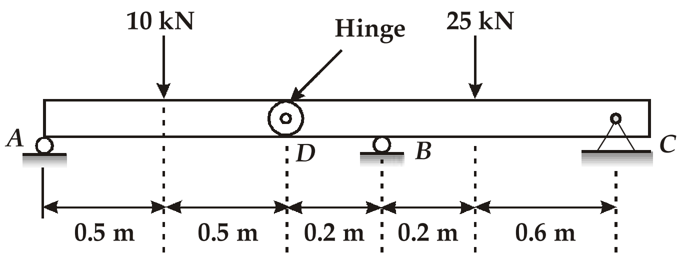
Ans. (a)



$$M_1 = +\frac{PL}{2} - \frac{PL}{2} = 0$$

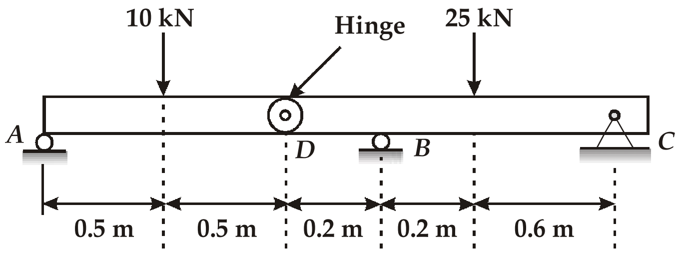
End of Solution

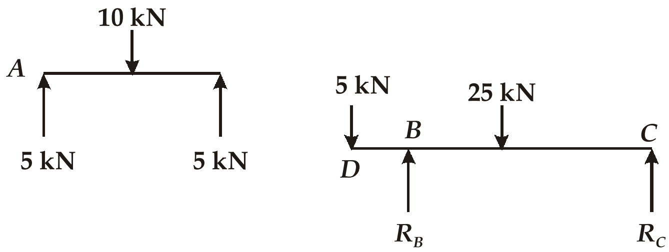
41. Two structural members are connected by a hinge and they are externally loaded as shown in the figure below. A and B are roller supports, and C is a pin support. Neglecting the mass of the members, the magnitude of the vertical reaction force at C in kN is



(a) 5
(b) 10
(c) 20
(d) 15

Ans. (a)





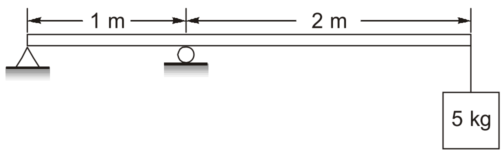
$\Sigma M_B = 0$

$$5 \times 0.2 + R_C \times 0.8 = 25 \times 0.2$$

$$R_C = 5 \text{ kN}$$

End of Solution

42. A 5 kg mass is suspended at the free end of an overhanging massless beam, having a pin support and a roller support, as shown in the figure below. Young's modulus of the material of the beam is 200 GPa and area moment of inertia of the beam is 10^{-8} m^4. The natural frequency of the beam in rad/s is



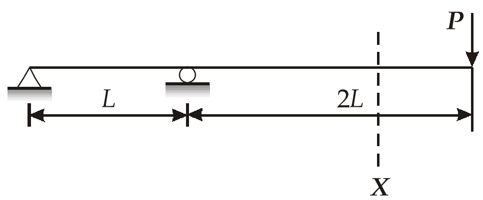
(a) 10
(b) 10/3
(c) 5
(d) 20/3

Ans. (a)

Given data: E = 200000 MPa, $I = 10^{-8}$ m^4, m = 5 kg,

$$EI = 200000 \times 10^{-8} \times 10^6 \text{ N/m}^2$$

$$= 2000 \text{ N/m}^2$$



Here, $L = 1$ m, $P = mg$

$$U = U_1 + U_2$$

$$U = \int_o^{2L} \frac{(Px)^2}{2EI} dx + \int_{2L}^{3L} \frac{(Px - 3P(x-2L))^2}{2EI} dx$$

$$= \int_o^{2L} \frac{P^2x^2}{2EI} dx + \int_{2L}^{3L} \frac{(6PL - 2Px)^2}{2EI} dx$$

$$= \frac{8P^2L^3}{6EI} - \left[\frac{4P^2(3L-x)^3}{6EI}\right]_{2L}^{3L}$$

$$= \frac{4P^2L^3}{3EI} + \frac{2P^2L^3}{3EI} = \frac{2P^2L^3}{EI}$$

$$\delta_{st} = \frac{\partial U}{\partial P} = \frac{4PL^3}{EI}$$

$$\omega_n = \sqrt{\frac{g}{\delta_{st}}} = \sqrt{\frac{gEI}{4PL^3}}$$

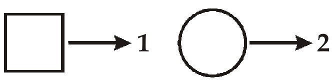
Substituting values, $\omega_n = \sqrt{\frac{gEI}{4mgL^3}} = \sqrt{\frac{2000}{4\times5\times1}} = 10$ rad/s

End of Solution

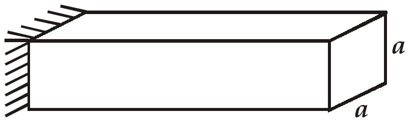
43. A very long fin of a uniform square cross-section is replaced by another very long fin of a uniform circular cross-section of the same material. Assume uniform and identical heat transfer coefficient for both the fins. If the diameter of the circular fin is equal to the side length of the square fin, then the ratio of heat transfer rates before and after the replacement is

(a) $4/\pi$ (b) $16/\pi^2$
(c) $1/\pi$ (d) $1/\pi^2$

Ans. (a)

Long fins, 

For square cross-section,



Given: $a = d$, $P = 4a = 4d$, $A_C = a^2 = d^2$

For circular cross-section,

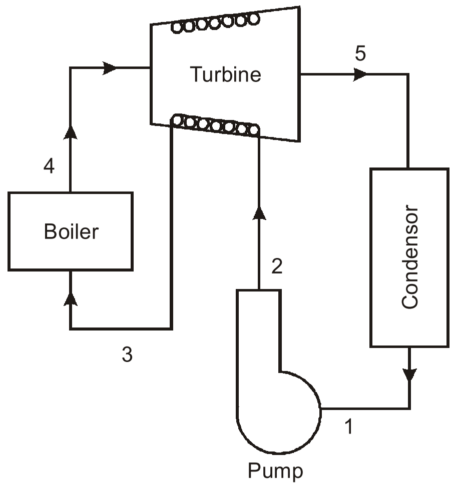
$$P = \pi d$$

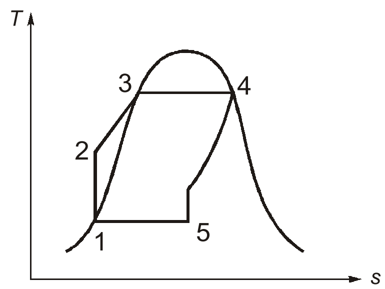
$$A_C = \frac{\pi d^2}{4}$$

$$\frac{q_1}{q_2} = \frac{\sqrt{hPkA_C}\,\theta_b}{\sqrt{hPkA_C}\,\theta_b} = \sqrt{\frac{16}{\pi^2}} = \frac{4}{\pi}$$

End of Solution

44. For an ideal regenerative Rankine cycle, as shown in the figure below, which one of the following options is the correct representation of temperature-entropy (T-s) diagram?



(a)


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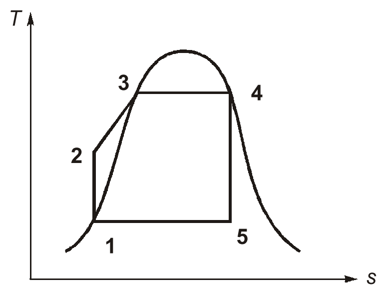

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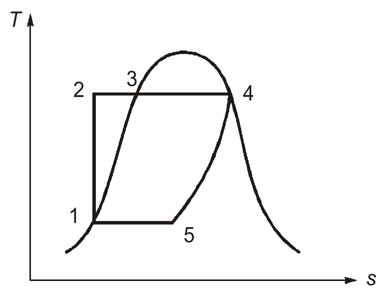

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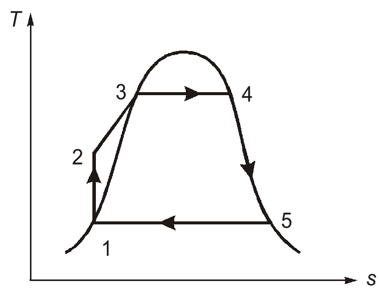

Ans. (a)

End of Solution

45. Consider the Euler variables of polyhedral objects namely, P_1, P_2, P_3, and P_4 as given in the table below.

Polyhedral Objects	Faces (F)	Edges (E)	Vertices (V)	Faces' inner loops (L)	Bodies (B)	Genus (G)
P1	6	12	8	0	1	0
P2	5	8	5	0	1	0
P3	5	12	8	0	1	0
P4	10	24	16	0	1	0

Which one of the following options is NOT a topologically valid closed polyhedral object as per Euler's law?

(a) P3
(b) P1
(c) P4
(d) P2

Ans. (a)

For a topologically valid closed polyhedral object as per Euler's law.

$$V - E + F = 2$$

For P_1, $F = 6,\ E = 12,\ V = 8$

$\therefore$ $8 - 12 + 6 = 2$ [Condition satisfied]

For P_2, $F = 5,\ E = 8,\ V = 5$

$\therefore$ $5 - 8 + 5 = 2$ [Condition satisfied]

For P_3, $F = 5,\ E = 12,\ V = 8$

$\therefore$ $8 - 12 + 15 = 2$ [Not satisfied]

For P_4, $F = 10,\ E = 24,\ V = 16$

$\therefore$ $16 - 24 + 10 = 2$ [Condition satisfied]

Hence, P_3 is not satisfying the Euler's law for closed polyhedral objects.

End of Solution

46. An objective function Z of primal variables (x_1 and x_2) is described below:

Minimize $Z = 0.07x_1 + 0.05x_2$

Subject to

$$0.1x_1 \geq .0.4$$
$$0.1x_2 \geq 0.6$$
$$0.1x_1 + 0.2x_2 \geq 2.0$$
$$0.2x_1 + 0.1x_2 \geq 1.8$$
$$x_1 > x_2 \geq 0$$

W is the objective function of the dual of Z.

k_1, k_2, k_3 and k_4 represent the corresponding dual variables.

Which one of the following options represents the correct form of W?

(a) Maximize $W = 0.4k_1 + 0.6k_2 + 2.0k_3 + 1.8k_4$

Subject to

$$0.1k_1 + 0.1k_3 + 0.2k_4 \leq 0.07$$
$$0.1k_2 + 0.2k_3 + 0.1k_4 \leq 0.05$$
$$k_1,\ k_2,\ k_3,\ k_4 \geq 0$$

(b) Maximize $W = 0.4k_1 + 0.6k_2 + 2.0k_3 + 1.8k_4$
Subject to
$0.1k_1 + 0.1k_2 + 0.2k_4 \le 0.07$
$0.1k_2 + 0.2k_3 + 0.1k_4 \le 0.05$
$k_1, k_2, k_3, k_4 \ge 0$

(c) Maximize $W = 0.4k_1 + 0.6k_2 + 2.0k_3 + 1.8k_4$
Subject to
$0.1k_1 + 0.1k_2 + 0.2k_4 \le 0.05$
$0.1k_1 + 0.2k_3 + 0.1k_4 \le 0.07$
$k_1, k_2, k_3, k_4 \ge 0$

(d) Maximize $W = 0.4k_1 + 0.6k_2 + 2.0k_3 + 1.8k_4$
Subject to
$0.1k_1 + 0.1k_3 + 0.2k_4 \le 0.05$
$0.1k_2 + 0.2k_3 + 0.1k_4 \le 0.07$
$k_1, k_2, k_3, k_4 \ge 0$

Ans. (a)

Primal

$$\text{Min } z = 0.07\,x_1 + 0.05x_2$$
$$0.1x_1 \ge 0.4 \;]\; y_1$$
$$0.1\,x_2 \ge 0.6 \;]\; y_2$$
$$0.1x_1 + 0.2x_2 \ge 2 \;]\; y_3$$
$$0.2x_1 + 0.1x_2 \ge 1.8 \;]\; y_4$$

Dual

Maximize $W = 0.4k_1 + 0.6k_2 + 2k_3 + 1.8k_4$

Subjected to,
$$0.1y_1 + 0.1y_3 + 0.2y_4 \le 0.07$$
$$0.1y_2 + 0.2y_3 + 0.1y_4 \le 0.05$$
$$y_1, y_2, y_3, y_4 \ge 0$$

End of Solution

47. Four jobs are on order in a factory. As on day 20 of the production calendar, the corresponding due date and work remaining to complete these jobs (in days) are given in the table below.

Job	Due date	Work remaining (in days)
M	26	5
N	24	10
O	28	10
P	31	5

Which job(s) has/have critical ratio less than unity?

(a) Job N and Job O
(b) Job M and Job N
(c) Job P
(d) Job O and Job P

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Ans. (a)

Given: Today's date = 20

As we know, Critical Ratio (C.R.) $= \dfrac{\text{Due date - Today's date}}{\text{Total shop time remaining}}$

For Job *M*, $(\text{C.R.})_M = \dfrac{26-20}{5} = 1.2$

Hence, $(\text{C.R.})_M > 1$

For Job *N*, $(\text{C.R.})_N = \dfrac{24-20}{10} = 0.4$

Hence, $(\text{C.R.})_N < 1$

For Job *O*, $(\text{C.R.})_O = \dfrac{28-20}{10} = 0.8$

Hence, $(\text{C.R.})_O < 1$

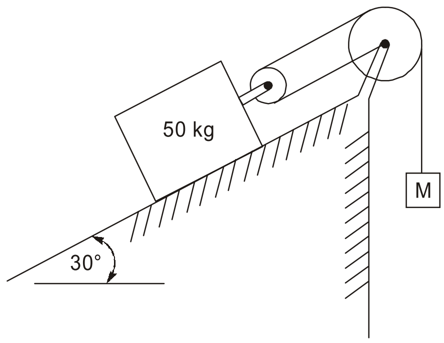
For Job *P*, $(\text{C.R.})_P = \dfrac{31-20}{5} = 2.2$

Hence, $(\text{C.R.})_P > 1$

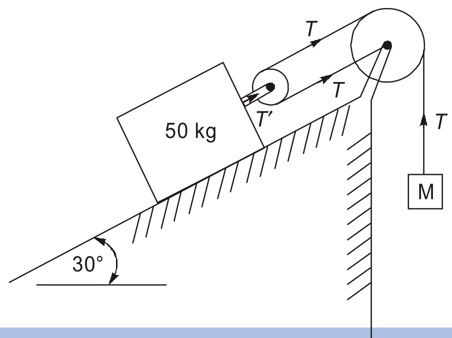
∴ Job *N* and Job *O* have critical ratio less than unity.

End of Solution

48. A block of 50 kg mass is on an inclined plane. The block is connected to another hanging mass M by an inextensible massless string through two massless pulleys as shown in the figure below. The coefficient of static friction between the block and the inclined plane is 0.3. Neglecting pulley friction, the minimum value of M required to start the upward motion of the block is ________ kg (rounded off to 1 decimal place).



Ans. (18.99) (18.5 to 19.5)



Given: m = 50 kg, μ = 0.3

For upwad motion of block, minimum value of M required, when mass M is verge of downward motion.

For verge $\Sigma\vec{F} = 0$

$$T' = Mg$$

$$Mg \sin 30° + \mu\, mg\cos 30° = T$$

and $T = 2T' = 2Mg$

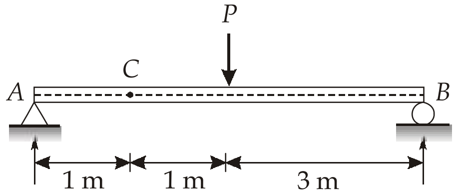
$$\Rightarrow mg \sin 30° + \mu\, mg\cos 30° = 2Mg$$

$$\Rightarrow \quad M = \frac{50(\sin 30° + \mu \cos 30°)}{2}$$

$$\Rightarrow \quad M = 18.99 \text{ kg}$$

End of Solution

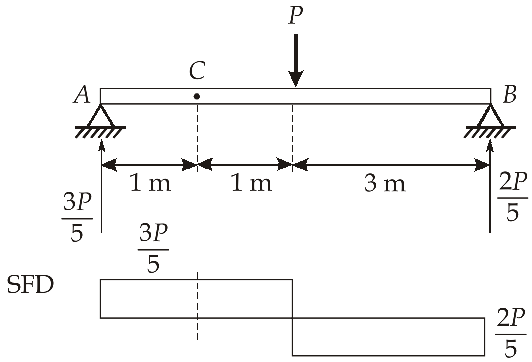
49. A simply supported beam is subjected to an external point load P as shown in the figure below. The beam has a rectangular cross-section of 20 mm × 45 mm. A is a pin support and B is a roller support. The shear stress developed at point C, lying on the neutral axis of the beam, is 3 MPa. Neglecting the mass of the beam, the magnitude of the applied load is _______ kN (rounded off to 1 decimal place).



Ans. (3) (2.9 to 3.1)

Given: Dimension of cross-section = 20 mm × 45 mm

Shear stress at point C, τ_C = 3 MPa



shear force at c, $= \frac{3P}{5}$

$$\tau_c = 1.5\frac{S_C}{A_C}$$

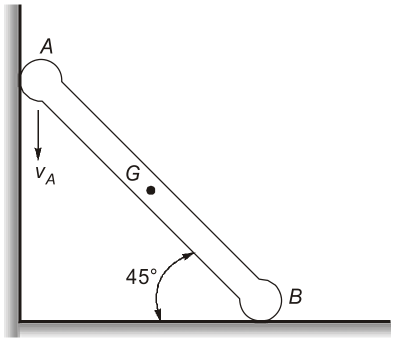
$$3 = \frac{1.5 \times \frac{3P}{5}}{20 \times 45}$$

$$P = 3000 \text{ N}$$

$$P = 3 \text{ kN}$$

End of Solution

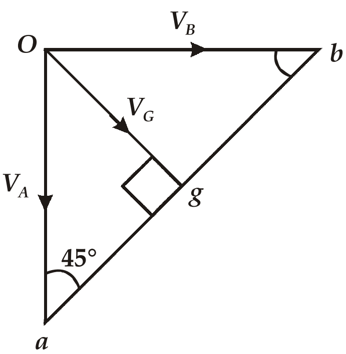
50. A rigid slender bar, AB, is sliding against two mutually perpendicular frictionless walls, as shown in the figure below. The velocity of A in the downward direction at a given instant is 6 m/s. At that instant, the magnitude of absolute velocity of the midpoint G is ________ m/s (rounded off to 2 decimal places).



Ans. (4.24) (4.20 to 4.29)

Given: $V_A = 6$ m/s.

Velocity diagram



$$\sin 45^\circ = \frac{V_G}{V_A} = \frac{V_G}{6}$$

$$\Rightarrow \quad \frac{1}{\sqrt{2}} = \frac{V_G}{6}$$

$$\Rightarrow \quad V_G = \frac{6}{\sqrt{2}} = 4.24 \text{ m/s}$$

End of Solution

51. A cylindrical pressure vessel made of steel has diameter of 3 m and wall thickness of 15 mm. For steel, Young's modulus and Poisson's ratio are 210 GPa and 0.3, respectively. The cylinder is designed such that the allowable normal strain at the outer cylindrical surface is equal to 0.00034. The permissible pressure in the tank is ________ kPa (rounded off to 1 decimal place).

Ans. (840) (838.0 to 842.0)

Given data: E = 210 GPa, μ = 0.3, t = 15 mm, d = 3 m, ϵ_h = 0.00034.

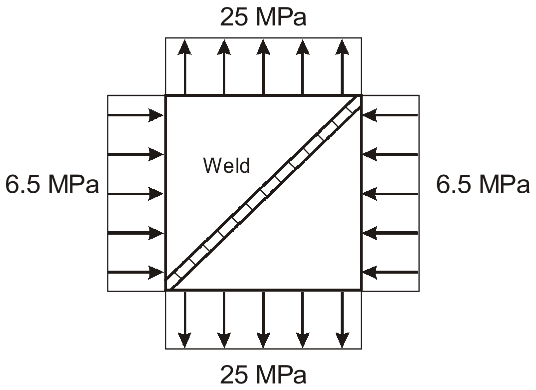
Now, $$\epsilon_h = \frac{pd}{4tE}(2-\mu)$$

$$0.00034 = \frac{p(300)(2-0.3)}{(4)(15)\times 210\times 10^3}$$

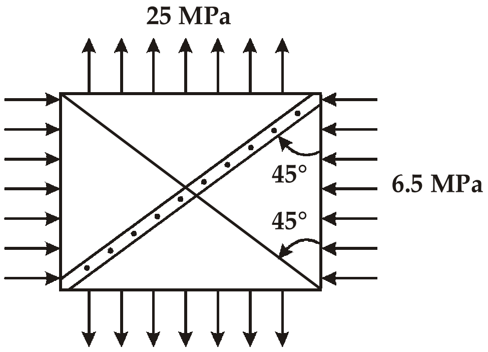
$$p = 0.84 \text{ MPa}$$
$$p = 840 \text{ kPa}$$

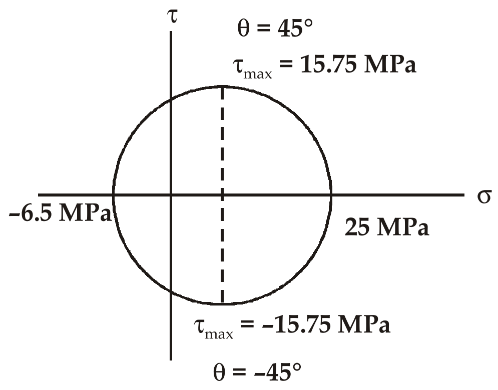
End of Solution

52. A welded square plate of 1 m × 1 m is subjected to biaxial stress of magnitude 6.5 MPa and 25 MPa, as shown in the figure below. The ratio of the normal stress acting in the perpendicular direction of the weld to the shear stress of the weld is ________ (rounded off to 2 decimal places).



Ans. (0.5873) (0.57 to 0.61)





$$\theta = -45 \text{ or } 135°$$

$$(\sigma_n)_{\theta = -45°} = \frac{25+(-6.5)}{2}$$

$$(\sigma_n)_{\theta = -45°} = 9.25 \text{ MPa}$$

$$(\tau_s)_{\theta} = -45° = -\left(\frac{25-(-6.5)}{2}\right) = -15.75 \text{ MPa}$$

$$\frac{\sigma_n}{\tau_s} = -\frac{9.25}{15.75} = -0.5873$$

$$\left|\frac{\sigma_n}{\tau_s}\right| = 0.5873$$ **Ans.**

End of Solution

53. Water with a density of 1000 kg/m^3 comes out of an industrial condenser through a horizontal pipe of 15 cm radius at the flow rate of 4.5 m^3/min. The outlet of the pipe is connected to a coaxial diffuser of 0.5 m length using a flange to raise the pressure of water to atmospheric condition without any backflow. The inner radius (r, in m) of the diffuser cross-section is expressed as

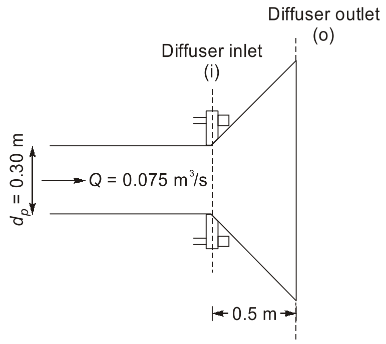
$$r = 0.15 + 0.4\,x^2$$

where, x represents the axial distance of the diffuser in m, from its inlet. Considering frictionless flow, the magnitude of the force exerted by the diffuser on the flange is ________ N (rounded off to 2 decimal places).

Ans. (16.29) (15.50 to 17.10)

Given: $\rho = 1000$ kg/m^3, $r_p = 0.15$ m, $Q = 4.5$ m^3/min $= 0.075$ m^3/s, $L_d = 0.5$ m.

For diffuser, $r = 0.15 + 0.4x^2$



At diffuser inlet, $V_i = \dfrac{Q}{A_i} = \dfrac{0.075}{\pi \times (r_i)^2}$ [At diffuser inlet $r_i = r_p = 0.15$ m]

$$V_i = \frac{0.075}{\pi \times (0.15)^2} = 1.061 \text{ m/s}$$

Also, At $L_d = 0.5$ m

$$r_o = 0.15 + 0.4 \times (0.5)^2 = 0.25 \text{ m}$$

$\therefore \qquad V_o = \dfrac{Q}{A_o} = \dfrac{0.075}{\pi \times (r_o)^2} = \dfrac{0.075}{\pi \times (0.25)^2} = 0.38197 \text{ m/s}$

By using Bernoulli's equation at inlet and outlet of the diffuser.

$$\frac{P_i}{\rho g} + \frac{V_i^2}{2g} + \cancel{Z_i} = \frac{P_o}{\rho g} + \frac{V_o^2}{2g} + \cancel{Z_o}$$

$$\frac{P_i}{1000} + \frac{(1.061)^2}{2} = \frac{(0.38197)^2}{2} \qquad (\text{As } P_o = P_{atm})$$

$$P_i = (0.07295 - 0.5629) \times 1000$$

$$P_i = -489.95 \text{ Pa}$$

Also, $\qquad (\Sigma F_{net})_x = [(\rho QV)_f]_x - [(\rho QV)_i]_x$

$$(P_i A_i)_x - (P_o A_o)_x - F_x = \rho Q V_o - \rho Q V_i$$

$$-489.95 \times \pi \times (0.15)^2 - F_x = 1000 \times 0.075\ (0.38197 - 1.061)$$

$$-34.6325 - F_x = -50.92725$$

$$F_x = 16.29 \text{ N}$$

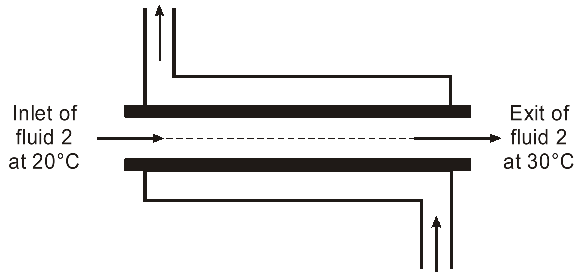
End of Solution

54. Two rectangular surfaces both having 1 m^2 area are placed perpendicular to each other with a common edge. One surface is hot, having a temperature of 1000 K and emissivity of 0.4, while the other is insulated and in radiant balance with a large surrounding room at 300 K. If the fraction of radiation leaving the hot surface which reaches the cold surface is 0.2, then the equivalent overall resistance for the radiation heat loss from the hot surface is _______ m^{-2} (rounded off to 2 decimal places).

Ans. (2.50 to 2.60)

End of Solution

55. Convective heat transfer coefficients for Fluid 1 and Fluid 2 in a heat exchanger, as shown in the figure below, are 50 W/(m^2K) and 80 W/(m^2K), respectively. The inner tube is made of a material which has a thermal conductivity 386 W/(m K) for the given range of temperatures in the heat exchanger. The length of the heat exchanging surface, the inside radius of the inner tube, and thickness of the inner tube are 1 m, 10 mm, and 1 mm, respectively. Considering no heat exchange between the outer tube and the surrounding, the heat transfer rate for the heat exchanger is ________ W (rounded off to 1 decimal place).



Ans. (50.06) (49.5 to 51.5)

Given: r_i = 10 mm, t = 1 mm, r_e = 11 mm, L = 1 m

$k_{\text{inner tube}}$ = 386 W/m°C

h_i = 80 W/m²°C, h_e = 50 W/m²°C

Conduction resistance of inner tube wall

$$R = \frac{\ln\left(\frac{r_e}{r_i}\right)}{2\pi kl} = \frac{\ln\left(\frac{11}{10}\right)}{2\pi \times 386 \times 1} = 3.92 \times 10^{-5} \text{ k/W}$$

Overall heat transfer coefficient,

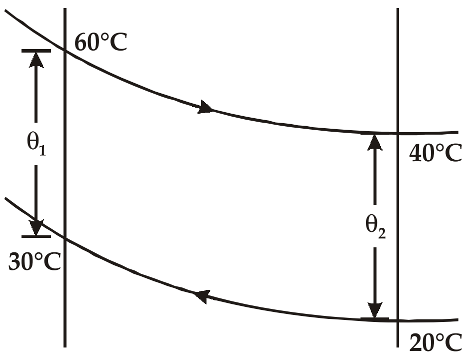
$$\frac{1}{UA} = \frac{1}{h_i A_i} + \frac{1}{h_e A_e} + R_{\text{conduction}}$$

Since, thickness is very less $\Rightarrow A_i \approx A_e$ and $R_{\text{conduction}}$ is also negligible.

$$\therefore \quad \frac{1}{U} = \frac{1}{h_i} + \frac{1}{h_e} = \frac{1}{80} + \frac{1}{50}$$

$$\Rightarrow \quad U = 30.77 \text{ W/m}^2\text{K}$$

Now, the given configuration is counter flow heat exchanger.



$$\theta_1 = T_{hi} - T_{c,o} = 30°\text{C}$$

$$\theta_2 = T_{ho} - T_{c,i} = 20°\text{C}$$

$$\text{LMTD} = \frac{\theta_1 - \theta_2}{\ln\left(\frac{\theta_1}{\theta_2}\right)} = \frac{10}{\ln(1.5)} = 24.66°C$$

$\therefore$ Heat transfer rate, $q = UA\,(\text{LMTD})$

$= U(\pi DL)\,(\text{LMTD})$ $\qquad \left\{D = \frac{D_i + D_e}{2}\right\}$

$= 30.77 \times (\pi \times 0.021 \times 1) \times 24.66$

$q = 50.06$ W

End of Solution

56. A liquid comes out of the reactor of a chemical plant at 250°C temperature with a flow rate of 100 LPM. The ambient temperature is 25°C. Density and specific heat of the liquid remain constant at 1000 kg/m^3 and 4.18 kJ/kg K, respectively, for the given range of temperature. The rate of exergy associated with the hot liquid stream at the exit of the plant is ________ kW (rounded off to 2 decimal places).

Ans. (400.54) (396.00 to 406.00)

Given: $Q = 100$ LPM $= 100 \times \frac{1}{1000 \times 60} = 1.67 \times 10^{-3}\ m^3/s$, $C_p = 4.18$ kJ/kgK, $\rho = 1000$ kg/m^3, $T_o = 25°C$, $T = 250°C$.

$$\psi = (h - h_o) - T_o\,(s_1 - s_2)$$

$$= C_pT - C_pT_o + T_oC_p \ln\left(\frac{T_o}{T}\right)$$

$$= 4.18 \times (523 - 298) + 298 \times 4.18 \times \ln\left(\frac{298}{523}\right)$$

$$= 940.5 - 700.6575 = 239.94 \text{ kJ/kg}$$

Rate of Exergy $= \dot{m} \times \psi = \rho \times Q \times \psi$

$= 1000 \times 1.67 \times 10^{-3} \times 239.84$

$= 400.54$ kW

End of Solution

57. A rigid closed vertical cylindrical vessel of 15 cm diameter contains 5 kg water at 80°C with 10% quality. The water is heated till its temperature reaches 130°C. Considering only a horizontal separated interface between liquid and vapor, the dip in the liquid level after the heating process is ________ cm (rounded off to 2 decimal places).
Properties of water at various saturation temperatures are given in the table below.

Temperature	Specific volume		Specific internal energy	
(T°C)	v_f (m^3/kg)	v_g (m^3/kg)	u_f (kJ/kg)	u_g (kJ/kg)
80	0.001029	3.4053	334.97	2481.60
130	0.001070	0.66808	546.10	2539.50

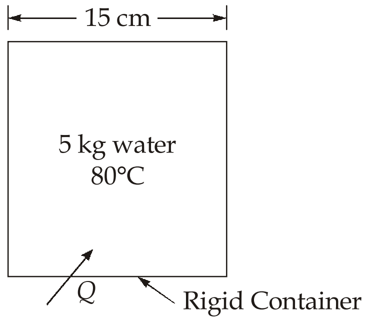
T, v and u ae temperatue, specific golume, and specific internal energy, respectively. subscripts f and g represent saturated liquid and saturated vapor, respectively.

Ans. (11.4) (11.00 to 11.90)

Given data

$x_1 = 0.1; \quad T_1 = 80°; \quad T_2 = 130°C$

@ 80°C (m³/kg)	@ 130°C (m³/kg)
$v_f = 0.001029$	$v_f = 0.001070$
$v_g = 3.4053$	$v_g = 0.66808$



$$v_1 = v_f + x_1 v_{fg} = 0.34145 \text{ m}^3/\text{kg}$$
$$v_1 = v_2$$
$$0.34145 = v_f + x_2(v_{fg})$$
$$x_2 = 0.5104$$
$$x_1 = \frac{m_v}{m_v + m_l}$$
$$1 - x_1 = 1 - \frac{m_v}{m_l + m_v} = \frac{m_{l_1}}{m_{v_1} + m_{l_1}}$$
$$1 - 0.1 = \frac{m_{l_1}}{5} \Rightarrow m_{l_1} = 4.5 \text{ kg}$$
$$1 - x_2 = \frac{m_{l_2}}{5}$$
$$m_{l_2} = 2.448 \text{ kg}$$
$$V_{l_1} = m_{l_1} \times (0.001029) = 4.63 \times 10^{-3} \text{ m}^3$$
$$V_{l_2} = m_{l_2} \times (0.001070) = 2.619 \times 10^{-3} \text{ m}^3$$
$$V_{l_1} - V_{l_2} = 2.0106 \times 10^{-3} \text{ m}^3$$
$$(H_1 - H_2) \times A = V_1 - V_2$$
$$(H_1 - H_2)\frac{\pi}{4}(0.15)^2 = 2.0106 \times 10^{-3}$$

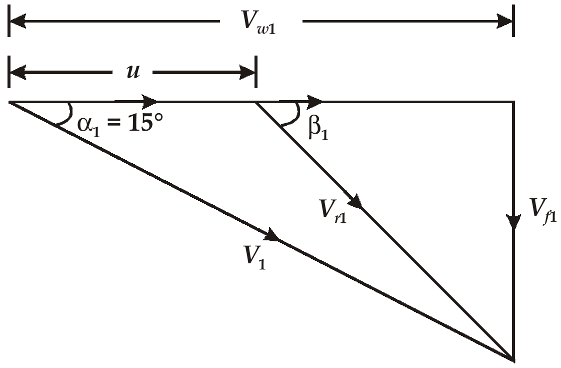
Change in height of the liquid level = 114×10^{-3} m = 11.4 cm

End of Solution

58. An inward flow reaction turbine, having an outer diameter of 1 m, runs at 600 RPM. The normal component of absolute velocity at the inlet is 10 m/s. If the guide blade angle is 15°, then the inlet vane angle of the runner is ________ degree (rounded off to 1 decimal place).

Ans. (59.44) (57.5 to 61.5)

Given: N = 600 rpm, D_o = 1 m, V_{f1} = 10 m/s, β_1 = ?, α_1 = 15°.



Inlet Velocity Triangle

$$u_1 = \frac{\pi D_o N}{60} = 10\pi \text{ m/s} = 31.4159 \text{ m/s}$$

$$\tan \alpha_1 = \frac{V_{f1}}{V_{w1}} \Rightarrow \tan 15° = \frac{10}{V_{w1}}$$

$$V_{w1} = \frac{10}{\tan 15°} = 37.3205 \text{ m/s}$$

$$\tan\beta_1 = \frac{V_{f1}}{V_{w1} - u_1} = \frac{11}{37.3205 - 31.4159}$$

$$\beta_1 = 59.44°$$

End of Solution

59. In a deep drawing operation of a rectangular sheet metal, 30% stretching in length results in 15% reduction in thickness. Assuming volume constancy, the normal anisotropy of the sheet metal is ________ (rounded off to 2 decimal places).

Ans. (0.61) (0.59 to 0.63)

$$\in_v = 0$$

$$\in_l + \in_t + \in_w = 0 \quad \text{... (i)}$$

$$\in_l = \ln\left(\frac{l_f}{l_o}\right) = \ln\left(\frac{1.3 l_o}{l_o}\right) = 0.2623$$

$$\in_t = \ln\left(\frac{t_f}{t_o}\right) = \ln\left(\frac{0.85 t_o}{t_o}\right) = -0.1625$$

$$\in_w = -(\in_t + \in_l) \quad \text{[From (i)]}$$

$$\in_w = -0.0988$$

Normal anisotropy, $r = \frac{\epsilon_w}{\epsilon_r} = \frac{-0.0988}{-0.1625} \cong 0.61$

End of Solution

60. The actual demand for castings in a factory is 500 units and 635 units for the months of January 2026 and February 2026, respectively. The forecasted demand for January 2026 is 250 units and smoothing constant is 0.7. Using the exponential smoothing method, the forecast of the demand for castings in March 2026 is________ units (in integer).

Ans. (572) (572 to 572)

Given, $\alpha = 0.7$

	D	F	e
Jan	500	250	250
FEB	635	425	210
March		572	

$$F_t = F_{t-1} + \alpha e_{t-1}$$

Forecast for the month of March = 572

End of Solution

61. The inventory holding cost of an item is Rs. 0.50 per unit per month and the ordering cost per order is Rs. 550. A stockist needs to supply 10000 units of the item per year to the customers. Assume demand is fixed and shortage cost is infinite. Using classical economic order quantity (EOQ) model, the optimal lot size is ________ units per order (rounded off to nearest integer).

Ans. (1354) (1353 to 1355)

Given: D = 10000 units/year, C_h = Rs. 0.5 /month = Rs. 6/year, C_o = Rs. 550

$$Q^* = \sqrt{\frac{2DC_o}{C_h}} = \sqrt{\frac{2 \times 10000 \times 550}{6}} \approx 1354 \text{ units}$$

End of Solution

62. A metal has FCC crystal structure with 2.71 g/cm^3 of density and 26.98 g/mol of atomic weight. The Avogadro's number is 6.023 × 10^{23}. The atomic radius of the metal is ________ nm (rounded off to 2 decimal places).

Ans. (0.1429) (0.12 to 0.16)

Given: FCC crystal structure (n_{av} = 4), ρ = 2.71 g/cm^3, M = 26.98 g/mol.

$$\rho = \frac{n_{av} \times At.Weight}{6.02 \times 10^{23} \times \left(\frac{4r}{\sqrt{2}}\right)^3}; \qquad \left\{\because \text{For FCC, } a = \frac{4r}{\sqrt{2}}\right\}$$

$$2.71\ \text{g/cm}^3 = \frac{4\times 26.98}{6.02\times 10^{23}\times\left(\frac{4r}{\sqrt{2}}\right)^3}$$

$$r^3 = 0.292159\times 10^{-23}\ \text{cm}^3$$

$$r = 0.1429\ \text{nm}$$

End of Solution

63. During orthogonal turning by using a single point cutting tool, feed rate is 0.24 mm/rev. The uncut chip thickness is 0.23 mm. The shear angle, tangential force component, and radial force component are 20°, 800 N, and 150 N, respectively. The value of shear force is ________ N (rounded off to 2 decimal places).

Ans. (700.451) (571.00 to 574.00)

Given: f = 0.24 mm/rev, ϕ = 20°, t_1 = 0.23 mm, F_T = 150 N, F_C = 800 N.

$$F_S = F_C\cos\phi - F_T\sin\phi$$
$$= 800\cos 20° - 150\sin 20°$$
$$= 700.451\ \text{N}$$

End of Solution

64. A drill bit during its lifetime can produce 150 through holes in a plate at a drill-speed of 200 RPM. If the drill-speed increases to 300 RPM, then it can produce 60 through holes in the same plate before the drill bit fails. Assume all other parameters remain constant. The value of the exponent in Taylor's tool life equation is ________ (rounded off to 2 decimal places).

Ans. (0.3067) (0.29 to 0.33)

Given data:

Number of holes	Rotation speed(RPM)
150	200
60	300

For drilling operation,

$$N_1T_1^n = N_2T_2^n$$

$$\text{Tool life} = \text{Number of holes}\left(\frac{L}{s\times N}\right)$$

$$\Rightarrow\quad 200\left[150\times\frac{L}{s\times 200}\right]^n = 300\left[60\times\frac{L}{s\times 300}\right]^n$$

$$\Rightarrow\quad (0.75)^n = 1.5\,(0.2)^n$$

$$\Rightarrow\quad n = \frac{\ln 1.5}{\ln 3.75} = 0.3067$$

End of Solution

65. The activities of a PERT network and their corresponding activity time estimates (in weeks) i.e., optimistic (t_o), most likely (t_m), and pessimistic (t_p) are given in the table below.

Activity	Time (in weeks)		
	t_o	t_m	t_p
1 - 2	2	4	12
1 - 3	2	4	6
1 - 4	3	4	11
2 - 5	3	6	9
3 - 4	2	5	14
3 - 5	3	3	3
4 - 5	3	6	15
5 - 6	2	5	8

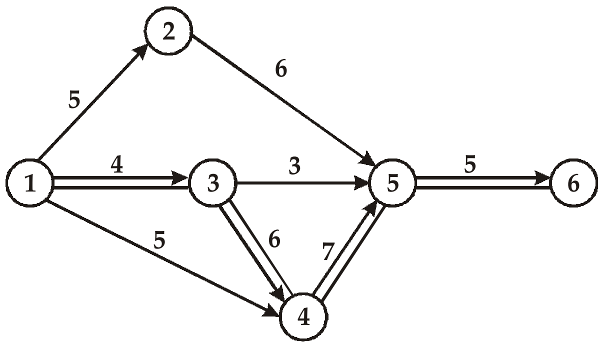
The expected project length is ________ weeks (in integer).

Ans. (22) (22 to 22)

We know that, $t_e = \dfrac{t_o + 4t_m + t_p}{6}$

Activities	Expected time(t_e)
1-2	5
1-3	4
1-4	5
2-5	6
3-4	6
3-5	3
4-5	7
5-6	5

Network



Critical path : 1-3-4-5-6

$(T_e)_{project} = 22$

End of Solution

■■■■

MADE EASY students top in ESE 2025

4 Streams 4 Toppers all 4 MADE EASY Students | **39 selections in Top 10** | **434 selections out of 458 Vacancies (95% Selections)**

CE — 9 in Top 10
- AIR 1 MOHAMMAD SHAQUIB — Live Online Foundation Course
- AIR 2 PRAKHAR SHRI — Classroom Foundation Course
- AIR 3 ARJUN SHARMA — Mains Online Course
- AIR 4 BOLLA U NANDAN — Classroom Foundation Course
- AIR 5 KESHAV — Test Series & IGP
- AIR 7 TUSHAR AGGARWAL — Classroom Foundation Course
- AIR 8 AYUSH JAIN — Classroom Foundation Course
- AIR 9 ADITYA P SINGH — Test Series & IGP
- AIR 10 PUSHPENDRA RATHORE — Test Series & IGP

ME — 10 in Top 10
- AIR 1 NIMESH CHANDRA — Classroom Foundation Course
- AIR 2 ASHOK KUMAR — Classroom Foundation Course
- AIR 3 HARI SINGH — Mains Online Course
- AIR 4 SIDDESH RAO — GS Online Course
- AIR 5 GOLLANGI SATEESH — Mains Online Course
- AIR 6 AVINASH VERMA — Mains Online Course
- AIR 7 PRASHANT SINGH — Mains Offline Course
- AIR 8 MONU KUMAR — Classroom Foundation Course
- AIR 9 NIKHIL KUMAR SAHA — Test Series & IGP
- AIR 10 AMIT KUMAR SINGH — Classroom Foundation Course

EE — 10 in Top 10
- AIR 1 RAJAN KUMAR — Classroom Foundation Course
- AIR 2 VISHNU SAINI — Live Online Foundation Course
- AIR 3 OMPRAKASH RAJPUT — Classroom Foundation Course
- AIR 4 TUSHAR CHAUDHARY — Classroom Foundation Course
- AIR 5 RAM KUMAR — Test Series & IGP
- AIR 6 PUNIT MEENA — Classroom Foundation Course
- AIR 7 JYOTI K. PANDA — Classroom Foundation Course
- AIR 8 D A SAI RAM REDDY — Test Series & IGP
- AIR 9 DHRUV KAWAT — Classroom Foundation Course
- AIR 10 AKSHIT PARASHARI — Live Online Foundation Course

E&T — 10 in Top 10
- AIR 1 UTKARSH PATHAK — Live Online Foundation Course
- AIR 2 RAJESH TIWARI — Live Online Foundation Course
- AIR 3 PRASHANT LAVANIA — Classroom Foundation Course
- AIR 4 PRADEEP SHUKLA — Mains Online Course
- AIR 5 ASHISH SINGH PATEL — Classroom Foundation Course
- AIR 6 TANYA TYAGI — Mains Online Course
- AIR 7 PALAK MISHRA — Mains Online Course
- AIR 8 HAYAT ALI — Classroom Foundation Course
- AIR 9 VIDHU SHREE — Live Online Foundation Course
- AIR 10 RAM PAL SINGH — Classroom Foundation Course

MADE EASY students top in GATE 2025

5 All India Rank 1 (CE, ME, IN, ES & EE) | **45 Selections in Top 10** | **399 Selections in Top 100**

- AIR 1 CE Abhay Singh — Classroom Course
- AIR 1 ME Rajneesh Bijarniya — Classroom Course
- AIR 1 EE Pradip Chauhan — Test Series
- AIR 1 IN Kailash Goyal — Classroom Course
- AIR 1 ES Yash Jain — Classroom Course
- AIR 2 CE Harshvardhan Singh — Classroom Course
- AIR 2 ME Gollangi Sateesh — Online Course
- AIR 2 EE Kailash Goyal — Classroom Course
- AIR 2 EC Ankush Philip John — Postal Package & Test Series
- AIR 2 IN S. Bhattacharya — Test Series
- AIR 2 ES Jitesh Choudhary — Classroom Course
- AIR 2 ES Tarun Yadav — Classroom Course
- AIR 3 CE Pankaj Meena — Classroom Course
- AIR 3 ME Nimesh Chandra — Classroom Course
- AIR 3 PI Aditya Kr. Prasad — Classroom Course
- AIR 3 XE Rohan Kr. Biswal — Test Series
- AIR 5 CE Kartik Pokhriyal — Classroom Course
- AIR 5 PI Kuldeep Singh Naruka — Classroom Course
- AIR 5 IN Sachin Yadav — Test Series
- AIR 5 EC M. M. Nafeez — Test Series
- AIR 5 ES Sachin Kumar — Classroom Course
- AIR 6 PI Kaushal Kr. Kaushik — Online Course
- AIR 6 CE Shivanand Chaurasia — Online Course
- AIR 6 CE Nimish Upadhyay — Online Course
- AIR 6 EE Puneet Soni — Test Series
- AIR 6 EE Shivam Kr. Gupta — Test Series
- AIR 6 EC Pentela J. Bhavani — Test Series
- AIR 6 IN Utkarsh P. Patil — Classroom Course
- AIR 7 PI Waleed Shaikh — Test Series
- AIR 7 ME Abhinn — Online Course
- AIR 7 IN Dev J. Patel — Test Series
- AIR 7 ES Ankit Kumar — Classroom Course
- AIR 8 ME Goutam Kumar — Test Series
- AIR 9 CE Tarun Yadav — Classroom Course
- AIR 9 CS Omhari — Test Series
- AIR 9 EC Chilukuri S. Charan — Test Series
- AIR 9 XE Apar Harsh Chandra — Classroom Course
- AIR 10 CE Adnan Quasain — Classroom Course
- AIR 10 CE Rahul Singh — Online Course
- AIR 10 ME Ashutosh Kumar — Classroom Course
- AIR 10 ME Jetti Ganateja — Test Series
- AIR 10 ME Muhammed Sinan K — Test Series
- AIR 10 ME Pitchika Kr. Vasu — Online Course
- AIR 10 PI M Gopu Ganesh — Test Series
- AIR 10 EE Neelava Mukherjee — Postal Package & Test Series

Course-wise details of "top 100 rank holders of GATE 2025" and "selected candidates of ESE 2025 from MADE EASY" are available on our website.

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