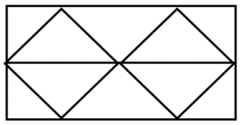
Real Test 01

Mechanical Engineering

Q1 In the figure shown below, various horizontal and vertical segments divide the outer shape into multiple regions. How many rectangles and triangles are there in the figure?



(A) Two rectangles & Twelve triangles
(B) Five rectangles & Ten triangles
(C) Six rectangles & Twelve triangles
(D) Eight rectangles & Eleven triangles

Q2 Train P leaves station A at 08:00 hours and reaches station B at 12:00 noon. Train Q leaves station B at 09:00 hours and reaches station A at 15:00 hours. Assuming both trains travel at constant speeds, at what exact time do the two trains cross each other?
(A) 10:15 hours
(B) 10:36 hours
(C) 10:48 hours
(D) 11:30 hours

Q3 Two fair dice are thrown simultaneously. In how many possible outcomes is the number shown on the top face of the first die greater than the number on the bottom face of the second die?
(A) 18 (B) 36
(C) 6 (D) 15

Q4 Select the most appropriate meaning of the underlined idiom.
The actor decided to live life **in the fast lane**.
(A) Racing away to the moon
(B) A life of extreme speed
(C) A life filled with excitement
(D) Dropping charges of crime

Q5 Select the most appropriate synonym of the given word.

LUCID
(A) Lucky (B) Timely
(C) Clear (D) Happy

Q6 Which of the following powers of 6 is the largest factor of : $1 \times 2 \times 3 \times 4 \times 5 \ldots\ldots\ldots \times 89 \times 90$.
(A) 6^{24} (B) 6^{44}
(C) 6^{34} (D) 6^{18}

Q7 In a bakery, Rohan can bake half as many cakes as Meera in one-sixth of the time it takes Meera. If they decide to work together, they can bake all the cakes in 10 days. How many days would Meera need to bake all the cakes by herself?
(A) 40 days (B) 25 days
(C) 30 days (D) 35 days

Q8 The given sentence contains a grammatical error. Identify the segment that contains the error.
Smitha was offered the job although having no qualifications.
(A) although having
(B) Smitha was offered
(C) the job
(D) no qualifications

Q9 A rectangular sheet of cardboard has its sides in the ratio 1:4. Riya keeps cutting it in half along the longer side. After several cuts, she wonders: after how many cuts will the rectangle again have the same 1:4 ratio of sides?
(A) 4 cuts (B) 6 cuts
(C) 3 cuts (D) Never

Q10 A chef intends to fill a display case with 20 cupcakes, reaching its full capacity. Every 30 seconds, he adds 2 cupcakes, but a mischievous helper takes 1 cupcake out. How much time will it take for all 20 cupcakes to be in the display case for the first time?
(A) 600 seconds (B) 328 seconds

(C) 570 seconds (D) 300 seconds

Q11 A billet that is 75 mm long with diameter = 35 mm is direct extruded to a diameter of 20 mm. The extrusion die has a die angle = 75°. For the work metal, K = 600 MPa and n = 0.25. In the Johnson extrusion strain equation, a = 0.8 and b = 1.4. The extrusion strain is ____. (round off to 2 decimal places)

Q12 A sample of moist air is at a temperature 'T' and relative humidity 50%. A part of the moisture is removed adiabatically by using an adsorbent. If the heat of absorption is negligible, the resulting air will have the same

(A) dry bulb temperature but a lower wet bulb temperature

(B) wet bulb temperature but a higher dry bulb temperature

(C) dry bulb temperature but a higher wet bulb temperature

(D) wet bulb temperature but a lower dry bulb temperature

Q13 Which one of the following expression holds true for kinematic chain having unconstrained motion? All symbols having their standard meaning.

(A) $\mathrm{j}+\frac{\mathrm{h}}{2}=\frac{3}{2}l+2$

(B) $\mathrm{j}-\frac{\mathrm{h}}{2}<\frac{3}{2}l-2$

(C) $\frac{\mathrm{j}}{2}+\mathrm{h}<\frac{3}{2}l-2$

(D) $\mathrm{j}+\frac{\mathrm{h}}{2}<\frac{3}{2}l-2$

Q14 A survey was conducted among 800 College students. The results for their preference for three subjects: Mathematics(M), Physics(P) and Chemistry(C) are as follows:

- 350 students like M, 300 students like P, 250 students like C.
- 150 students like both M and P, 100 students like both P and C.
- 120 students like both M and C.
- 70 students like all three subjects (M, P and C)

How many students do not like any of the three subjects?

(A) 600 (B) 370

(C) 450 (D) 200

Q15 Median life of a taper bearing under equivalent load of 15 kN is 20 mR. Dynamic load carrying capacity of the bearing is:

(A) 36.847 kN (B) 22.736 kN

(C) 40.710 kN (D) 23.811 kN

Q16 Two men, one stronger than the other have to lift a load of 1200 N which is suspended from a light rod of length 3m. The load is suspended between the two persons positioned at the two ends of the rod. The weaker of the two persons can carry a load upto 400 N only. The distance of the load to be suspended from the stronger person, such that the weaker person can have the full share of 400 N, is

(A) 0.5 m (B) 1.0 m

(C) 1.5 m (D) 2.0 m

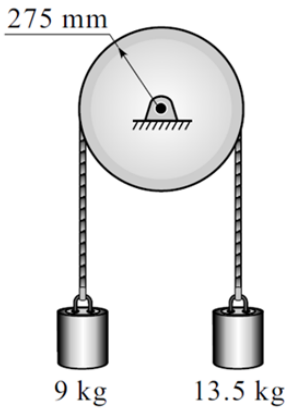
Q17 The ratio of bulk modulus to shear modulus of an isotropic elastic material is $\frac{5}{3}$. Poisson's ratio of the material is _____. (Round off to two decimal places)

Q18 A ball of mass m moving with the velocity u collided head on with another ball of mass m at rest. The coefficient of restitution is e. The ratio of velocity of first and second ball after collision is given by

(A) $\frac{1+e}{1-e}$ (B) $\frac{1+e}{2}$

(C) $\frac{1-e}{2}$ (D) $\frac{1-e}{1+e}$

Q19 Two blocks of 9 kg and 13.5 kg are suspended on two ends of a string passing over a pulley of radius 275 mm as shown in figure. The blocks are of negligible size and the mass moment of inertia of the pulley about its center, where it is hinged, is 4 kg – m^2. The angular acceleration of the pulley is ____ rad/s^2. (Round off to two decimal places) Assume g = 10 m/s^2.



Q20 $L = \lim_{x \to 0} \left(\frac{1}{x}\right)^{\tan x}$

(A) L = 0 (B) $L = \frac{1}{e}$

(C) L = e (D) L = 1

Q21 In a polytropic expansion process the ratio of final volume to its initial volume is 2 and ratio of final temperature to initial temperature is $\frac{1}{2}$, then the polytropic index of expansion is

(A) 0 (B) 1

(C) 2 (D) 1.3

Q22 A machine component under fluctuating stress condition is considered to be safe, if the mean stress σ_m (in MPa) and amplitude stress, σ_a (in MPa). Satisfying the following inequality.

$\frac{\sigma_m}{400} + \frac{\sigma_a}{200} \leq 1$

The machine component is subjected to repeated stress, whose maximum value is σ. For safe operation which one of the following inequality should satisfy:

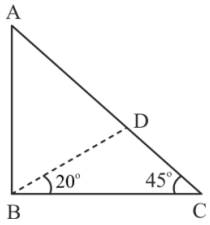
(A) $\sigma \leq \frac{800}{3}\ MPa$

(B) $\sigma \geq \frac{800}{3}\ MPa$

(C) $\sigma \leq \frac{400}{3}\ MPa$

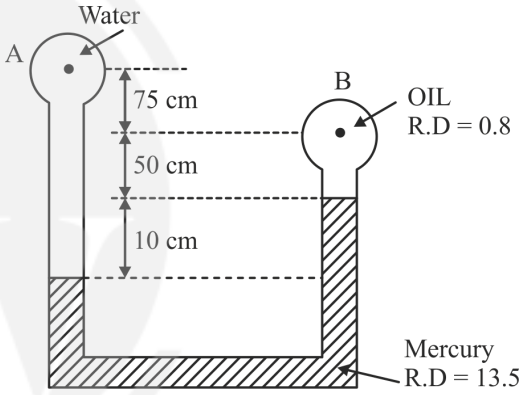
(D) $\sigma \geq \frac{400}{3}\ MPa$

Q23 The throat of a fillet weld is 15 mm. Thickness of fillet weld (thickness BD) at an angle 20° from Leg BC as shown in figure is _____ mm [Round off to the two decimal places]



Q24 The power developed by a turbine in a certain steam power plant is 1200 kW. The heat supplied to the boiler is 3360 kJ/kg. The heat rejected by the system to the cooling water is 2520 kJ/kg and feed pump work required to pump the condensate back into the boiler is 6 kW. The steam flow through the cycle in kg/s is _____ kg/s (round off to two decimal places).

Q25 A differential manometer is connected to two different pressure points shown in figure below.



The nearest value of (P_A – P_B) in kPa is _____ (answer in integer).

Q26 Which of the following thing(s) occurred during grain growth is/are

(A) Large sized grains shrinks and small sized grains grows.

(B) Small sized grains shrinks and large sized grains grows.

(C) Grain boundary moves in the direction of atomic motion.

(D) Grain boundary moves opposite to the direction of atomic motion.

Q27 A new linear temperature scale, denoted by °S, has been developed, where the freezing point of water is 200°S and the boiling point is 400°S. On

this scale, 500°S corresponds, in degrees Celsius, to _____ (answer in integer).

Q28 Let X and Y be two independent random variables. Var (X) = 4 and Var(Y) = 9. Choose the correct option(s) given below.
(A) Var(2X) = 8
(B) Var(X - Y) = 13
(C) Var(2X - 3Y) = 97
(D) Var(Y/3) = 1

Q29 In an arc welding process, the power source has a constant voltage characteristic given by

V = 40 – 0.02I

where

- V = arc voltage in volts
- I = arc current in amperes

Assuming arc power is given by

P = VI

The value of current (in amperes) at which the arc power is maximum is _____(correct upto 2 decimal places)

Q30 During a blanking operation of a mild steel sheet, if diameter of the blank is increased by 40% and thickness is reduced by 8%, the required percentage increase in punching force is _____ (round off to 2 decimal places)

Q31 The ductility and strength of crystal structure BCC, FCC, HCP crystal in increasing order are:
(A) Ductility : BCC < HCP < FCC
Strength : FCC < HCP < BCC

(B) Ductility : HCP < BCC < FCC
Strength : FCC < BCC < HCP

(C) Ductility : FCC < BCC < HCP
Strength : HCP < BCC < FCC

(D) Ductility : FCC = BCC < HCP
Strength : HCP < FCC = BCC

Q32 The equation of the streamline, passing through the origin, in a flow field $u = \cos(\alpha)$, $v = \sin(\alpha)$ for a constant α is determined as
(A) $y = x^3$
(B) $y = x \cot^2 \alpha$
(C) $y = x \tan \alpha$
(D) $y = \alpha \sin x$

Q33 A perfectly insulated rigid tank of volume 5 m^3 is initially empty. It is then connected to a supply of nitrogen gas at pressure of 25 bar and temperature 30°C. The nitrogen flow stops when pressure in tank reaches 25 bar assuming nitrogen to behave as an ideal gas with γ= 1.4, the final temperature of nitrogen in tank is
(A) 42°C
(B) –56°C
(C) 30°C
(D) 151°C

Q34 Which one of the following manufacturing processes will likely result in the best surface finish:
(A) Arc welding (B) Grinding
(C) Machining (D) Sand casting

Q35 Recently, a meteorite hit the upper atmosphere at 3000 m/s, where the pressure is 0.1 atm, and the temperature is –40°C. Approximately, how hot does the air become right in front of the meteorite, assuming no heat transfer in this adiabatic stagnation process? Take C_P of air = $1.293\ \text{kJ}/\text{kgK}$. Assume constant specific heat.
(A) 4715 K (B) 1733 K
(C) 2518 K (D) 3713 K

Q36 Slip gauges (Indian standard set given below) have to be built up to a height of 10.35 mm. The most appropriate combination of slip gauges is:

Range (mm)	Steps (mm)	No. of pieces
1.001–1.009	0.001	9
1.01–1.49	0.01	49
0.5–9.5	0.5	19
10–90	10	9
	Total	**86**

(A) 8.00 + 1.30 + 1.05

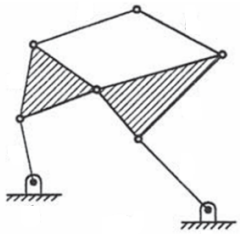
(B) 10.00 + 0.35
(C) 9.00 + 1.35
(D) 10.00 + 0.30 + 0.05

Q37 A gas expands according to equation P = $-250\ V\ +\ 600$, where V is in m^3 and P is in kPa. If gas expands from 0.1 m^3 to 0.4 m^3, then the work done is _____ kJ (round off to two decimal places).

Q38 In sand-mould casting of a metal, it takes 180 seconds for complete solidification of 27 cm^3 cube shaped casting. All other parameters remaining constant, the total solidification time (in seconds) for a cylindrical shaped [Diameter = 2 cm & height = 6 cm] casting of the same metal is

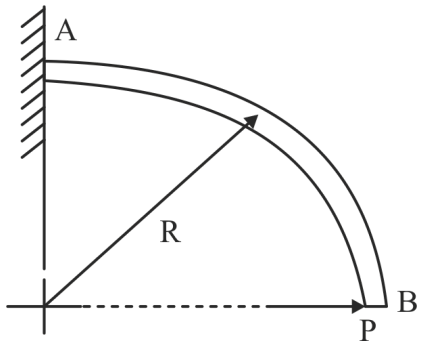
(A) 132.20 sec (B) 230.20 sec
(C) 30.02 sec (D) 60.02 sec

Q39 Which of the following statement(s) is/are correct regarding given mechanism?



(A) There are two ternary links.
(B) DOF of the mechanism is 1.
(C) DOF of the mechanism is 2.
(D) There are 4 ternary joints.

Q40 The curved beam shown in the figure is subjected to a concentrated force P in the horizontal direction at B. Flexural rigidity of the beam is EI. Which one or more of the following options is/are correct?



(A) Strain energy stored in the beam is $\frac{\pi}{8}\frac{P^2R^3}{EI}$
(B) Strain energy stored in the beam is $\left(\frac{3\pi}{8}-1\right)\frac{P^2R^3}{EI}$
(C) Horizontal displacement of point B is $\frac{\pi}{4}\frac{PR^3}{EI}$
(D) Horizontal displacement of point B is $\left(\frac{3\pi}{4}-2\right)\frac{PR^3}{EI}$

Q41 The minimum total elapsed time required to complete the following jobs on Machine M_1 and Machine M_2 in the order M_1, M_2 is _____. (in integers)

Job	1	2	3	4	5	6	7	8
Machine M_1 time	7	3	6	8	9	5	4	3
Machine M_2 time	8	8	2	4	7	5	6	8

Q42 A Pelton wheel has to be designed for the following data.
Power to be developed = 6 MW
Net head available = 300 m
Rotational speed = 550 rpm
Ratio of jet diameter to wheel diameter $= \frac{1}{10}$
Overall efficiency = 85%
Speed ratio $\left(\frac{u}{V_1}\right) = 0.46$
The number of jets required is _____. (Round of to the nearest integer)

Q43 The following data is given:

Annual demand = 8000 units,
Ordering cost = Rs. 15,
Unit holding cost = Rs. 0.06,
Lead time = 10 days,
Assume number of working days per year = 250.

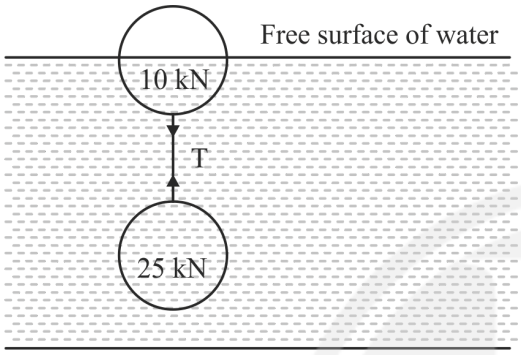
The Economic order quantity and re-order level respectively are

(A) 2000, 220 (B) 200, 22

(C) 2000, 320 (D) 200, 32.

Q44 Two spheres weighing 10 kN and 25 kN are each 1.6 m in diameter. They are connected by a short rope and placed in water as shown in figure.

Which one or more of the following statement(s) is/are Correct?



(A) Tension in the connecting rope is 3.91 kN to 4.05 kN.

(B) Tension in the connecting rope is 4.91 kN to 5.05 kN.

(C) The volume of lighter sphere will protrude above the free surface is 0.68 m^3 to 0.74 m^3.

(D) The volume of lighter sphere will protrude above the free surface is 0.58 m^3 to 0.64 m^3.

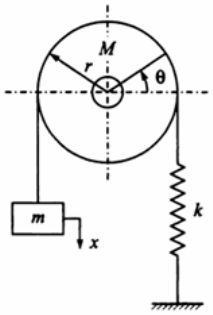
Q45 Consider the following D.E:

y" + y = sin(t)

with initial conditions as y(0) = 0 and y' (0) = 0.

The value of y (π) is____(Round off to two decimal places)

Q46 A mass m is suspended by a string wrapped around a pulley of mass M, radius r, and moment of inertia I. The other side of the pulley is connected to a linear spring with stiffness k, as shown in the provided figure below. If the system is set into small vertical oscillations, which of the following expressions represents the natural frequency (ω_n) of the system ?



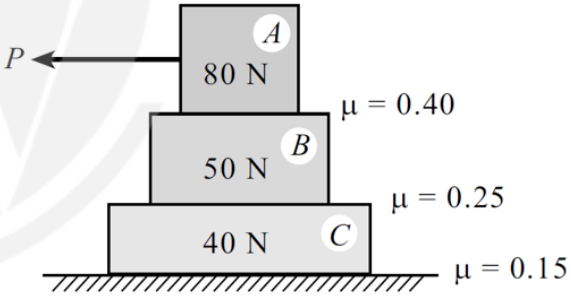
(A) $\omega_n = \sqrt{\frac{k}{m+\frac{I}{r^2}}}$

(B) $\omega_n = \sqrt{\frac{kr^2}{mr^2+I}}$

(C) $\omega_n = \sqrt{\frac{k}{m+M}}$

(D) $\omega_n = \sqrt{\frac{2k}{2m+M}}$

Q47 Three blocks A, B and C weighing 80 N, 50 N and 40 N respectively are placed on the surface one above the other as shown in figure. The static coefficient of friction between the blocks and block C and surface is also shown. The maximum value of P that can be applied without moving any of the blocks is ____ N. (Round off to two decimal places)



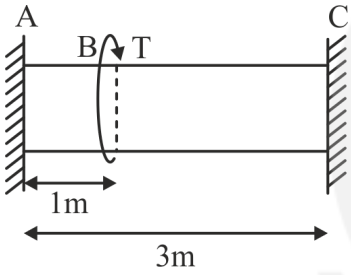
Q48 The shaft of a stepper motor is directly connected to a lead screw that drives a worktable in an x-y positioning system. The motor has a step angle = 5°. The pitch of the lead screw is 6 mm, which means that the worktable moves in the direction of the lead screw axis by a distance of 6 mm for each complete revolution of the screw.

It is desired to move the worktable a distance of 300 mm at a top speed of 40 mm/sec. The pulse frequency required to achieve this movement is _____Hz (Correct upto two decimal places).

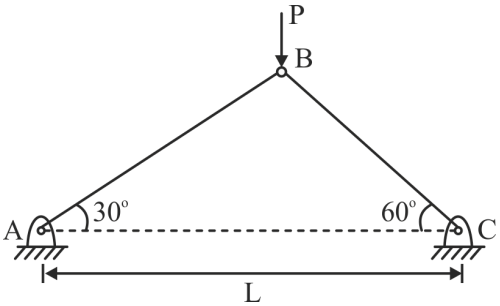
Q49 Which of the following statement(s) is/are TRUE?
(A) PERT analysis has three times estimation.
(B) One time estimate is required for any activity in developing CPM network
(C) Three time estimate is required for any activity in developing CPM network
(D) PERT has deterministic technique.

Q50 If a, b and c are the roots of $x^3 - 5x + 3 = 0$, then the value of the determinant $\begin{vmatrix} a & b & c \\ b & c & a \\ c & a & b \end{vmatrix}$ is equal to_____.

Q51 A solid steel shaft of diameter 80mm is fixed at ends A and C and subjected to torque T at B. The permissible shear stress of the shaft material is 80 MPa.
Permissible value of torque T is _____ kNm.
(Round off to two decimal places)



Q52 The truss member shown in the figure is subjected to a concentrated load P at point B. The flexural rigidity of both member AB and BC is EI. The maximum allowable value of load P to avoid buckling is:



(A) $\frac{8\pi^2 EI}{\sqrt{3}L^2}$
(B) $\frac{8\pi^2 EI}{3L^2}$
(C) $\frac{8\pi^2 EI}{L^2}$
(D) $\frac{8\pi^2 EI}{3\sqrt{3}L^2}$

Q53 Water is discharged from a tank maintained at a constant head of 5 m above the exit of a straight pipe 100 m long 150 mm diameter. If the friction coefficient for the pipe is given as 0.01,the rate of flow is_____ liters/sec (answer in integer). Minor losses accounted.

Q54 A thermocouple indicates a steady state temperature of 600°C when it is placed in a long duct where a hot gas is flowing at 720°C. If the convective heat transfer coefficient between the thermocouple and the gas is 60 W/m^{2}K and the emissivity for the thermocouple junction is 0.5, the duct wall temperature is _____°C(Round off to 2 decimal places)

Q55 Ice cream at a temperature of –18°C is being transported through a refrigerated truck having outside dimensions of 6 m in length, 3 m in width, and 2 m in height. The truck is travelling at a speed of 90 km/h on a highway where the air temperature is 45°C. The truck is insulated in a way such that the outside surface temperature of the truck is maintained at 15°C. Assume that there is no heat transfer from the front and back of the truck. Properties of air at 30°C are: ρ = 1.1514 kg/m^3, $\mu = 1.86 \times 10^{-5}$ Pa·s, C_p = 1.007 kJ/kgK, k = 0.0265 W/mK. Use the relation $Nu = 0.036\ Re^{0.8}\ Pr^{0.33}$. The rate of heat transfer at the four surfaces is _____ kW(Round off to 2 decimal places).

Q56 The value of the following series $\frac{1}{2} - \frac{1}{6} + \frac{1}{24} - \frac{1}{120} + \ldots\ldots\ldots\ldots$ is _____ ***(Round off to two decimal places)***.

Q57 An orthogonal cutting operation is carried out with:
uncut chip thickness, $t_o = 0.10$ mm
Width of cut, b = 5 mm,
Chip thickness, t_c = 0.20 mm,
Cutting velocity, V = 2 m/s,
Rake angle, α = 15°,
Cutting force ,F_c = 500 N,

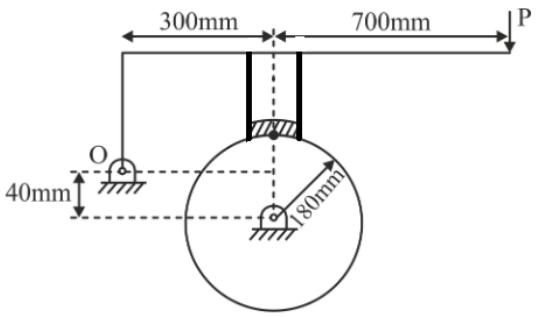
Thrust force, $F_t = 200$ N.
The percentage of total cutting energy dissipated in the shear plane is (in %) _____ (correct upto 2 decimal places)

Q58 Consider the system of linear equations
x + y + 5z = 3
x + 2y + 2z = 5
2x + 4y + 4z = k
For the system to have infinitely many solutions, the value of k is ____ (Enter in integer)

Q59 The moving-average forecast and actual demand for a hospital drug are as shown in the accompanying table. The tracking signal of the given forecast is:

Month	Actual Demand	Forecast Demand	Deviation	Cumulative Deviation
17	71	78	–7	–7
18	80	75	5	–2
19	101	83	18	16
20	84	84	0	16
21	60	88	–28	–12
22	73	85	–12	–24

Q60 In the short shoe brake as shown in the figure, coefficient of friction between the brake shoe and the drum is 0.25. The required braking torque on the drum is 300 N-m. Brake is self-energizing brake. Braking effort P is _____ N. [Round off to the two decimal places]

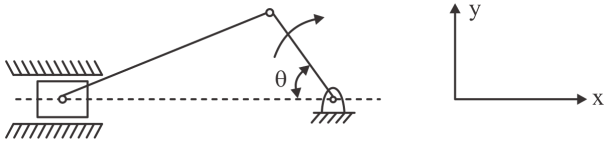


Q61 A steel ball 10 mm in diameter and initially at 900°C is placed in air at 30°C. For steel, density (ρ) = 7800 kg/m^3, specific heat (c) = 460 J/kgK, thermal conductivity (k) = 40 W/mK, and convective heat transfer coefficient is 20 W/m^{2}K. Instantaneous rate of heat transfer at 30 seconds is _____watt (Round off 2 decimal places).

Q62 An engine working on the Otto cycle has a clearance of 17 percent of stroke volume and initial pressure of 0.95 bar and a temperature of 30°C. Pressure at the end of the constant volume heating is 28 bar. The relative efficiency of the engine is 50% and the calorific value of the fuel used is 41900 kJ. Which of the following statements are correct?
(A) Air standard efficiency of this cycle ranges from 53.5% to 54.5%
(B) Air standard efficiency of this cycle ranges from 43.5% to 44.5%
(C) Maximum temperature in the cycle ranges from 1295 K to 1300 K
(D) Maximum temperature in the cycle ranges from 1165 K to 1175 K

Q63 The inverse Laplace transform is given as
$L^{-1}\left\{\frac{s+3}{s^2-4s+13}\right\} = e^{2t}\left\{\cos 3t + \alpha \cdot \sin 3t\right\}$
The value of 'α' is _____ (Round off to three decimal places)

Q64 A steam engine is as shown in figure. Piston has stroke length of 600 mm. Length of connecting rod is 1.5 metre. If mass of piston is 250 kg, the inertia force on the crank shaft, when crank has rotated by 30° from inner dead center with 120 rpm speed, is _____ kN [Round off to the two decimal places]
Note: (give your answer with direction: +ve for +x direction, –ve for –x direction).



Q65 A face milling operation is used to machine 5.0 mm from the top surface of a rectangular piece of aluminum 250 mm long by 125 mm wide in a

single pass. The cutter follows a path that is centered over the workpiece. It has eight teeth and is 150 mm in diameter. Cutting speed = 4 m/s, and chip load(feed per tooth) = 0.5 mm/tooth. Determine the actual machining time(s) to make the pass across the surface and the maximum metal removal rate during cutting (mm^3/s) respectively

(A) 8.359, 5300
(B) 8.359, 21200
(C) 2.359, 5300
(D) 8.359, 3500

Answer Key

Q1	(B)
Q2	(C)
Q3	(D)
Q4	(C)
Q5	(C)
Q6	(B)
Q7	(A)
Q8	(A)
Q9	(D)
Q10	(C)
Q11	2.3~2.45
Q12	(B)
Q13	(D)
Q14	(D)
Q15	(B)
Q16	(B)
Q17	0.24~0.26
Q18	(D)
Q19	2.1~2.2
Q20	(D)
Q21	(C)
Q22	(A)
Q23	16.45~16.65
Q24	1.38~1.44
Q25	3~5
Q26	(B, D)
Q27	149~151
Q28	(B, C, D)
Q29	1000~1000
Q30	28.7~28.9
Q31	(B)
Q32	(C)
Q33	(D)
Q34	(B)
Q35	(D)
Q36	(C)
Q37	159.35~164.35
Q38	(A)
Q39	(A, C)
Q40	(A, C)
Q41	51~51
Q42	2~4
Q43	(C)
Q44	(A, C)
Q45	1.5~1.6
Q46	(D)
Q47	25~26
Q48	479~481
Q49	(A, B)
Q50	0~0
Q51	11.06~13.06
Q52	(B)
Q53	58~64
Q54	483~484
Q55	95~96
Q56	0.35~0.38
Q57	63~73
Q58	10~10
Q59	-2.09~-2.01
Q60	1930.33~1936.33

Q61 4.5~5.5

Q62 (A, C)

Q63 1.6~1.67

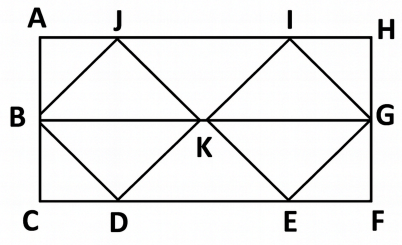
Q64 -11.62~-11.2

Q65 (B)

Hints & Solutions

Q1 Text Solution:

Pointing the figure as



The Rectangles are :

ABGH, BCFG, ACFH, BDKJ & KEGI. Total 5.

The Triangles are:

ABJ, BJK, JKI, IKG, IHG, BCD, BDK, KDE, KEG & GEF. Total 10.

Q2 Text Solution:

If the distance between Stations A and B is D km

Train P speed = D/4 (covers in 4 hours i.e. 0800 to 1200)

Train Q speed = D/6 (covers in 6 hours i.e. 0900 to 1500)

To reach the meeting point, Distance covered by Train P + Distance covered by Train Q = Total Distance (D).

Let's say they meet after 'x' hours from 0800.

Thus, x(D/4) + (x-1) (D/6) = D

Or (x/4) + (x-1 / 6) = 1

Or 3x + 2x – 2 = 12

Or 5x = 14

Thus x =14/5 = 2 and 4/5 hours = 2 hours 48 minutes

From 0800, 2 hours 48 minutes = 10:48 hours

Q3 Text Solution:

If top face of 1st die is 2, then second die is 1 (Only 1 case)

If top face of 1st die is 3, then second die is 1 or 2 (2 cases)

If top face of 1st die is 4, then second die is 1 or 2 or 3 (3 cases)

Similarly, If top face of 1st die is 5, then 4 cases

If top face of 1st die is , then 5 cases.

Total 1 + 2 + 3 + 4 + 5 = 15

Q4 Text Solution:

The idiom "live life in the fast lane" means a life filled with excitement → Option C.

Q5 Text Solution:

Lucid means easy to understand, clear, transparent in meaning or thought.

Q6 Text Solution:

As 6 is formed by the product of 3 and 2. Also number of 3's is less as compared to 2's. So, as many 3's those many 6's are formed.

To find in 90!

$\frac{90}{3}$ gives 30

$\frac{30}{3}$ gives 10

$\frac{10}{3}$ gives 3 (whole number)

$\frac{3}{3}$ gives 1

And $\frac{1}{3}$ gives 0 (whole number).

Thus total 30 + 10 + 3 + 1 = 44. Thus 90! has largest factor 6^{44}.

Q7 Text Solution:

If Meera bakes 1 cake in 1 unit time, Rohan bakes ½ cake in $\frac{1}{6}$ unit time.

Or Rohan bakes 1 cake $\frac{2}{6}$ unit time.

Comparing Time taken to do the work

Meera : Rohan = 1 : $\frac{1}{3}$ = 3 : 1

If Rohan takes x days, Meera takes 3x days.

Given that they do together the work in 10 days,

i.e. $\left(\frac{1}{x}\right) + \left(\frac{1}{3x}\right) = \frac{1}{10}$

Or $\left(\frac{4}{3x}\right) = \frac{1}{10}$ Or $\frac{3x}{4}$= 10 Or x = $\frac{40}{3}$.

Thus Meera takes $3\left(\frac{40}{3}\right)$ = 40 days.

Q8 Text Solution:

"Although" is a conjunction and must be followed by a subject + finite verb (e.g., "although she had no qualifications").

Here it is incorrectly followed by just the participle "having", so the phrase is ungrammatical.

Correct versions would be:

- "Smitha was offered the job although she had no qualifications."
- "Smitha was offered the job despite having no qualifications.

Q9 Text Solution:

Initial ratio 1 : 4.

Always cutting the longer side.

1st Cut ratio 1 : 2

2nd Cut ratio 1 : 1

3rd cut ratio (any side) 2 : 1.

4th Cut ratio again 1 : 1.

Thus Never it will come again to same ratio 1 : 4.

Q10 Text Solution:

In 30 seconds net cupcakes in display = 1 (2-1)

1 cup cake in 30 seconds

18 cupcakes in 30 × 18 = 540 seconds.

In the next 30 seconds chef adds 2 cupcakes to make it 20.

Thus total earliest time = 540 + 30 = 570 seconds.

Note: The last moment can't be withdrawal as the display holds only 20 cupcakes.

Q11 Text Solution:

(a) $r_x = A_o/A_f = D_o^2/D_f^2 = (35)^2/(20)^2 = 3.0625$

(b) $\varepsilon = \ln r_x = \ln 3.0625 = 1.119$

(c) $\varepsilon_x = a + b \ln r_x = 0.8 + 1.4(1.119) = 2.367$

Q12 Text Solution:

Heat is absorbed so it is absorption or chemical process in which WBT remains constant & DBT increases.

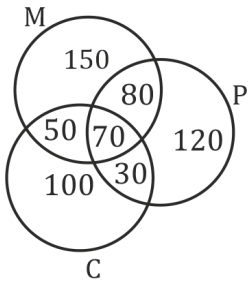
Q13 Text Solution:

The kinematic chain having unconstrained motion then this inequality must be hold true:

$j + \frac{h}{2} < \frac{3}{2}l - 2$

Q14 Text Solution:

Total students = 800



No. of students like at least one subject

= No. of students like one subjects + No. of students like two subjects + No. of students like all three subjects

= (150 + 120 + 100) + (50 + 30 + 80) + (70) = 600

No. of students who like none of the subjects = 800 – 600 = 200

Q15 Text Solution:

Given data:

Equivalent load, P = 15 kN

Median life of bearings, L_{av} = 20 mR

Dynamic Load Carrying capacity, C = ?

Rated life, L_{90} or $L = \frac{L_{av}}{5} = \frac{20}{5}$

$\Rightarrow L = 4\ mR$

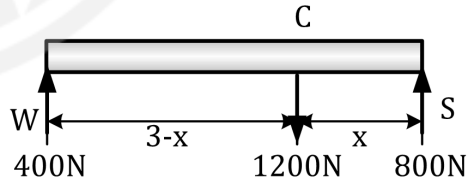
For taper roller bearing,

$L = \left(\frac{C}{P}\right)^{10/3}$

$\Rightarrow 4 = \left(\frac{C}{15}\right)^{10/3}$

$\Rightarrow$ C = 22.736 kN

Q16 Text Solution:



Load shared by stronger person

= 1200 – 400 = 800 N

Taking moment about left end;

800 × 3 –1200(3 – x) = 0

$\Rightarrow$x = 1 m

Q17 Text Solution:

$\frac{K}{G} = \frac{5}{3}$ (Given)

$\mu = ?$

$E = 2G(1+\mu) = 3K(1-2\mu)$

$\Longrightarrow 2\left(1+\mu\right) = 3 \times \frac{K}{G}\left(1-2\mu\right)$

$\Rightarrow 2+2\mu = 3\times\frac{5}{3}(1-2\mu)$
$\Rightarrow 2+2\mu = 5-10\mu$
$\Rightarrow 12\mu = 3$
$\Rightarrow \mu = \frac{3}{12}$
$\Rightarrow \mu = 0.25$

Q18 Text Solution:

$u_2 = 0$

From conservation of momentum,

$mu_1 + mu_2 = mv_1 + mv_2$

$\Rightarrow u_1 = v_1 + v_2 \quad \ldots.(i)$

From coefficient of restitution,

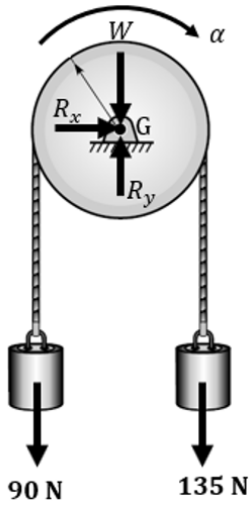
$e = \frac{v_2-v_1}{u_1-u_2} = \frac{v_2-v_1}{u_1-0}$

$\Rightarrow v_2 - v_1 = eu_1 \quad \ldots. (ii)$

By solving equation (i) and (ii)

$\Rightarrow \quad \frac{v_1}{v_2} = \frac{1-e}{1+e}$

Q19 Text Solution:



$\Sigma M_G = I_G\alpha$
$\Rightarrow 135\times 0.275 - 90\times 0.275$
$= \left(4 + 13.5\times 0.275^2 + 9\times 0.275^2\right)\alpha$
$\Rightarrow \alpha = 2.17 \text{ rad/s}^2$

Q20 Text Solution:

$L = \lim_{x\to 0}\left(\frac{1}{x}\right)^{\tan x}$

Take log both side

$\ln L = \lim_{x\to 0} \tan x\left(-\ln x\right) = \lim_{x\to 0}\frac{-\ln x}{\cot x},$

$\left(\frac{\infty}{\infty}\right)$form

using L'hospital rule

$\lim_{x\to 0}\frac{-\frac{1}{x}}{-\operatorname{cosec}^2 x} = \lim_{x\to 0}\left(\frac{\sin^2 x}{x}\right)$
$= \lim_{x\to 0}\left(\frac{\sin x}{x}\cdot \sin x\right) = 0$
$\ln L = 0$
$L = e^0 = 1$

Q21 Text Solution:

$T_1V_1^{n-1} = T_2V_2^{n-1}$
$\left(\frac{V_1}{V_2}\right)^{n-1} = \frac{T_2}{T_1}$
$(n-1)\log\frac{V_1}{V_2} = \log\frac{T_2}{T_1}$
$n = 1 + \frac{\log T_2/T_1}{\log V_1/V_2}$
$= 1 + \frac{\log 1/2}{\log 1/2} = 2$

Q22 Text Solution:

Given data:

For Safe Condition:

$\frac{\sigma_m}{400} + \frac{\sigma_a}{200} \le 1 \quad \ldots\ldots (1)$

0 to σ (Repeated stress)

Mean stress (σ_m):

$\sigma_m = \frac{\sigma_{max}+\sigma_{min}}{2} = \frac{\sigma+0}{2} = \frac{\sigma}{2}$

Amplitude stress (σ_a):

$\sigma_a = \frac{\sigma_{max}-\sigma_{min}}{2} = \frac{\sigma-0}{2} = \frac{\sigma}{2}$

from equation (i)

$\frac{\sigma}{2\times 400} + \frac{\sigma}{2\times 200} \le 1$
$\Rightarrow \sigma\left(\frac{1}{800} + \frac{1}{400}\right) \le 1$
$\Rightarrow \sigma \le \frac{800}{3}\ MPa$

Q23 Text Solution:

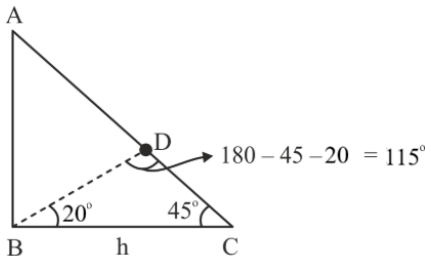
Given data:

Throat thickness, $t = 15$ mm

Thickness of fillet weld, $t_{BD} = ?$

Now,

$t = \frac{h}{\sqrt{2}}$
$\Rightarrow 15 = \frac{h}{\sqrt{2}}$
$\Rightarrow h = 21.23$ mm



from ΔBCD

$\Rightarrow \frac{t_{BD}}{\sin\ 45^\circ} = \frac{h}{\sin 115^\circ}$

$\Rightarrow \frac{t_{BD}}{\sin\ 45^\circ} = \frac{21.213}{\sin 115^\circ}$

$\Rightarrow\ t_{BC} = 16.55\ mm$

Q24 Text Solution:

From first law of thermodynamics

$\oint \delta Q = \oint \delta W$

$\dot{Q}_S + \dot{Q}_R = \dot{W}_T + \dot{W}_P$

$\dot{m}\,(q_s + q_R) = \dot{W}_T + \dot{W}_P$

$\dot{m} = \frac{1200-6}{3360-2520} = 1.42\ \text{kg/s}$

(∴ q_R is -ve as heat is rejected)

Q25 Text Solution:

Doing pressure balance

$P_A + (1 \times 9.81 \times 1.35) = P_B + (13.55 \times 9.81 \times 0.1) + (0.8 \times 9.81 \times 0.5)$

$\therefore P_A - P_B = 4\ \text{kN/m}^2$

Q26 Text Solution:

Grain growth occurs to reduce total grain boundary energy. This is driven by curvature differences of grain boundaries.

A. Large sized grains shrinks and small sized grains grows is incorrect. This is opposite of what happens.

B. Small sized grains shrinks and large sized grains grows is Correct.

- Small grains have higher curvature → higher energy
- They shrink and are consumed by large grains

C. Grain boundary moves in the direction of atomic motion is Incorrect.

D. Grain boundary moves opposite to the direction of atomic motion is Correct.

- Atoms diffuse from small grains → large grains
- Grain boundary migrates towards the small grain, i.e., opposite to atomic diffusion direction

Q27 Text Solution:

$\frac{\text{C}-\text{LFP}}{\text{UFP}-\text{LFP}} = \frac{\text{S}-\text{LFP}}{\text{UFP}-\text{LFP}}$

$\frac{\text{C}-0}{100-0} = \frac{500-200}{400-200}$

$\frac{\text{C}}{100} = \frac{300}{200}$

C = 150°C

Q28 Text Solution:

1. $\text{Var}(aX) = a^2(\text{Var}(X))$

2. for independent X and Y

$\text{Var}\,(aX \pm bY) = a^2\text{Var}\,(X) + b^2\text{Var}\,(Y)$

(A) $\text{Var}\,(2X) = 2^2 \times \text{Var}\,(X) = 4 \times 4 = 16$

(B) $\text{Var}\,(X - Y) = \text{Var}\,(X) + \text{Var}\,(Y) = 4 + 9 = 13$

(C)

$\text{Var}\,(2X + 3Y) = 2^2\text{Var}\,(X) + 3^2\text{Var}\,(Y)$

$= 4 \times 4 + 9 \times 9 = 97$

(D) $\text{Var}\left(\frac{Y}{3}\right) = \text{Var}\left(\frac{1}{3}Y\right) = \left(\frac{1}{3}\right)^2\text{Var}Y = \frac{1}{9} \times 9 = 1$

Q29 Text Solution:

Given:

V = 40 – 0.02I

Arc power:

P = VI = I(40 – 0.02I)

$P = 40I - 0.02\ I^2$

For maximum power:

$\frac{dP}{dI} = 0$

$\frac{dP}{dI} = 40 - 0.04I = 0$

$0.04I = 40$

$I = \frac{40}{0.04} = 1000\ \text{A}$

Q30 Text Solution:

$t_2 = 0.92t_1$

The punching force is given by

$F = \pi dt\tau$

Therefore, $F \propto dt$

$F_2 = 1.4 \times 0.92\ F_1 = 1.288\ F_1$

Thus, punching force is increased by 28.8%.

Q31 Text Solution:

Ductility depends mainly on the number of active slip systems:

- **HCP**: Very limited slip systems (mainly basal) → **least ductile**
- **BCC**: Many slip systems, but not all are easily activated at room temperature → **moderate ductility**
- **FCC**: 12 easily activated slip systems → **highest ductility**

So, increasing order of ductility: HCP < BCC < FCC

Strength (intrinsic lattice resistance to dislocation motion):

- **FCC**: Lowest lattice friction stress → **lowest strength**
- **BCC**: Higher Peierls stress than FCC → **moderate strength**
- **HCP**: Highest resistance due to limited slip → **highest strength**

So, increasing order of strength: FCC < BCC < HCP

Q32 Text Solution:

Stream line equation

$\frac{dx}{u} = \frac{dy}{v}$

$\frac{dx}{\cos\alpha} = \frac{dy}{\sin\alpha}$, Integrating both sides,

$\sin\ \alpha.\ x = \cos\ \alpha.\ y + c$

where $x = 0; y = 0 \Rightarrow c = 0$

$\sin\ \alpha.\ x = \cos\ \alpha.\ y$

$\therefore\ y = x\ \tan\ \alpha$

Q33 Text Solution:

$T_2 = \gamma T_1 = 1.4 \times 303 = 424.2$ K

$\Rightarrow T_2 = 151.2°C$

Q34 Text Solution:

Grinding is a finishing process that uses fine abrasive particles and very small material removal, resulting in very low surface roughness and high dimensional accuracy.

- Arc welding → Very rough surface due to molten metal solidification
- Machining (turning, milling, etc.) → Good finish, but generally inferior to grinding
- Sand casting → Rough surface due to sand mold texture
- Grinding → Best surface finish among the given options

Q35 Text Solution:

Energy Equation

$h_1 + \frac{1}{2}V_1^2 + gZ_1 = h_2 + \frac{1}{2}V_2^2 + gZ_2$

Process: $Z_1 = Z_2$ and $V_2 = 0$

$h_2 = h_1 + \frac{1}{2}V_1^2$

$T_2 = T_1 + \frac{1}{2} \times \left(\frac{V_1^2}{C_p}\right)$

$= 233 + \frac{1}{2} \times \frac{3000^2}{1.293 \times 1000} = 3713.27$ K

Q36 Text Solution:

The combination for this height is

9 + 1.35 = 10.35 mm (Minimum number of slip gauges).

Q37 Text Solution:

$_1W_2 = \int_{V_1}^{V_2} PdV =$

$\int_{0.1}^{0.4} (-250V + 600)\, dV$

$= -250\left[\frac{V^2}{2}\right]_{0.1}^{0.4} + 600[V]_{0.1}^{0.4}$

$= -125(0.4^2 - 0.1^2) + 600(0.4 - 0.1)$

$= -18.75 + 180 = 161.25$ kJ

Q38 Text Solution:

Given:

$\tau_{cu} = 180$ sec

$V_{cu} = 27\ cm^3 \Rightarrow a = 3\ cm,\ \tau_{cy} = ?$

$r_{cy} = 1\ cm,\ h_{cy} = 6\ cm$

$\left(\frac{\tau_{cy}}{\tau_{cu}}\right) = \left[\frac{\left(\frac{V}{A}\right)_{cy}}{\left(\frac{V}{A}\right)_{cu}}\right]^2$

$\left(\frac{\tau_{cy}}{\tau_{cu}}\right) = \left[\frac{\left(\frac{\pi r^2 h}{2\pi rh + 2\pi r^2}\right)_{cy}}{\left(\frac{a^3}{6a^2}\right)_{cu}}\right]^2$

$\frac{\tau_{cy}}{180} = \left[\frac{\frac{\pi \times 1^2 \times 6}{(2\pi \times 1 \times 6) + (2 \times \pi \times 1^2)}}{\frac{27}{6 \times 3^2}}\right]^2$

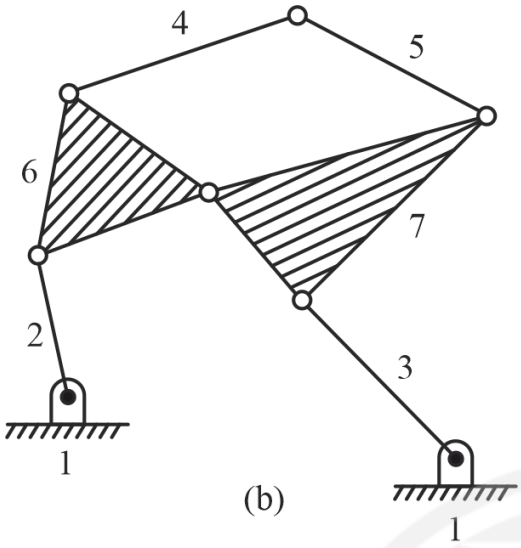
$\tau_{cy} = \left[\frac{0.4285}{0.5}\right]^2 \times 180$

$\tau_{cy} = 132.20$ sec

Q39 Text Solution:

Given data:

Configuration diagram of mechanism



Number of links l = 7

number of binary pairs, j = 8

Number of higher pairs, h = 0

From the Kutzbach Equation:

F = 3(l – 1) – 2j – h

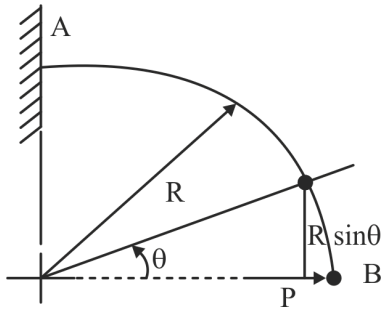
F = 3 (7 – 1) – 2 × 8 – 0

$\boxed{F = 2}$

And only link 6, 7 are ternary links.

Links 1, 2, 3, 4, 5 are binary links.

Q40 Text Solution:



AB segment,

Bending moment at an angle θ from B (M_θ),

M_θ = PR Sin θ

Strain energy (U),

$U = U_{AB} = \int_{AB} \frac{M_\theta^2 \times R d\theta}{2EI}$

$\Rightarrow U = \int_0^{\frac{\pi}{2}} \frac{(PR\ \sin\theta)^2 \times R d\theta}{2EI}$

$\Longrightarrow U = \frac{P^2R^3}{2EI} \int_0^{\frac{\pi}{2}} \sin^2\ \theta\ d\theta$

$\Rightarrow U = \frac{P^2R^3}{2EI} \int_0^{\frac{\pi}{2}} \frac{1-\cos 2\theta}{2}\ d\theta$

$\Rightarrow U = \frac{P^2R^3}{4EI} \left[\theta - \frac{\sin 2\theta}{2}\right]_0^{\frac{\pi}{2}}$

$\Rightarrow U = \frac{P^2R^3}{4EI} \left[\left(\frac{\pi}{2} - 0\right) - (0 - 0)\right]$

$\Rightarrow U = \frac{\pi P^2R^3}{8EI}$

Horizontal displacement of point B $(\delta_{B,H})$

Since at point B, the force P is applied in a horizontal direction, therefore

$U = \frac{1}{2} P \delta_{B,H}$

$\frac{\pi}{8} \frac{P^2R^3}{EI} = \frac{1}{2} \times P\delta_{B,H}$

$\delta_{B,H} = \frac{\pi}{4} \frac{PR^3}{EI}$

Q41 Text Solution:

The optimum sequence of jobs is: 2 – 8 – 7 – 6 – 1 – 5 – 4 – 3.

The detailed in–out times on the two machines are:

Job	M_1 In	M_1 Out	M_2 In	M_2 Out
2	0	3	3	11
8	3	6	11	19
7	6	10	19	25
6	10	15	25	30
1	15	22	30	38
5	22	31	38	45
4	31	39	45	49
3	39	45	49	51

Q42 Text Solution:

$\eta_0 = 0.85 = \frac{S.P.}{\gamma\, QH_{net}}$

$Q_t = \frac{6 \times 10^3}{9.81 \times 0.85 \times 300}$

$Q_t = 2.3985 \frac{m^3}{s}$

Discharge from one nozzle

Q = A × V_1

$= \frac{\pi}{4} d^2 \times V_1$

$V_1 = C_v \sqrt{2\, g H_{net}}$

$V_1 = \sqrt{2 \times 9.81 \times 300} = 76.72 \frac{m}{s}$

$\frac{d}{D} = \frac{1}{10}, \frac{u}{V_1} = 0.46$

u = 0.46 × 76.72=35.291 m/s

$\frac{\pi DN}{60} = 35.291$

$D = \frac{60 \times 35.291}{3.141 \times 550}$

D = 1.2255 m

d = 0.1225 m

Discharge per Nozzle

$Q = \frac{\pi}{4} \times 0.1225^2 \times 76.72$

$= 0.90375 \frac{m^3}{s}$

No of Nozzle

$= \frac{\text{Total Discharge}}{\text{Discharge per nozzle}} = \frac{2.3985}{0.90375} = 2.65 \approx 3$

Q43 Text Solution:

Annual demand (D) = 8000 units

Cost per order (C_o) = Rs. 15

Unit holding cost (C_c) = 0.06

Lead time = 10 days

$EOQ = \sqrt{\frac{2C_oD}{C_c}} = \sqrt{\frac{2 \times 15 \times 8000}{0.06}} = 2000$

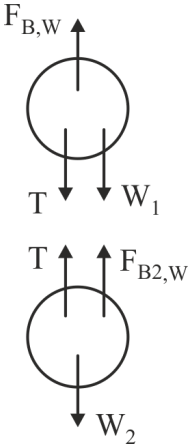
Reorder level = consumption rate × lead time

$= \frac{\text{Annual demand}}{\text{Number of working days}} \times \text{lead time}$

$= \frac{8000}{250} \times 10 = 320$ units

Q44 Text Solution:

For Equilibrium,



$W_2 = T + F_{B2,W}$

$\Rightarrow T = W_2 - F_{B2,W}$

$\Rightarrow T = 25 \times 10^3 - \{10^3 \times g \times \forall_2\}$

$T = 25 - \left\{g \times \frac{4}{3} \times \pi \times (0.8)^3\right\} kN$

$\Rightarrow T = 3.96$ kN

For Sphere-1;

$F_{B1} = T + W_1$

$\Rightarrow \rho_w g \forall_{sub} = (3.96 + 10) 10^3$

$\Rightarrow \forall_{sub} = \frac{13.96}{9.81} m^3$

$\Rightarrow \forall_{sub} = 1.423\ m^3$

$\forall_{Protude} = \forall_1 - \forall_{sub}$

$= \frac{4}{3}\pi (0.8)^3 - 1.423$

$\Rightarrow \forall_{protude} = 0.721\ m^3$

Q45 Text Solution:

Given: DE is $(D^2 + 1)\ y = \sin t$

A.E: $D^2 + 1 = 0$

$D = \pm i$

$\Rightarrow y_c = c_1 \cos t + c_2 \sin t$

$PI: \left(y_p\right) = \frac{1}{D^2+1} \sin\left(t\right)$ $D^2 \to -1^2$

$= \frac{1}{-1+1} \sin\left(t\right)$ (Denominator = 0)

$= \frac{t}{2D} \sin t = \frac{t}{2}(-\cos t) = -\frac{t}{2} \cos t$

$y = y_c + y_P$

$y = c_1 \cos t + c_2 \sin t - \frac{t}{2} \cos t$

$y(0) = c_1 \times 1 + 0 - 0$

$\Rightarrow \boxed{0 = c_1}$

$y' = -c_1 \sin t + c_2 \cos t - \frac{1}{2} \cos t$

$- \frac{t}{2}(-\sin t)$

$y'(0) = -0 + c_2 - \frac{1}{2}$

$0 = c_2 - \frac{1}{2}$

$\Rightarrow \boxed{c_2 = \frac{1}{2}}$

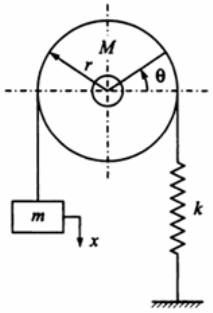
$y = \frac{1}{2} \sin t - \frac{t}{2} \cos t$

$y(\pi) = \frac{1}{2} \sin \pi - \frac{\pi}{2} \cos \pi = \frac{\pi}{2} = 1.57$

Q46 Text Solution:

given data:

Configuration diagram



from Energy Method:

Total kinetic energy (K.E.) = kinetic energy of mass m + kinetic energy of pulley of mass M.

Thus

$\text{K.E.} = \frac{1}{2}\text{m}\dot{\text{x}}^2 + \frac{1}{2}\text{I}\dot{\theta}^2$

Where,

$\dot{\text{x}} =$ velocity of mass $= \text{r}\dot{\theta}$.

$\dot{\theta}$ =angular velocity of pulley to produce above velocity of mass.

Therefore,

$\text{K.E.} = \frac{1}{2}\text{m}\left(\text{r}\dot{\theta}\right)^2 + \frac{1}{2}\text{I}\dot{\theta}^2$

$= \frac{1}{2}\left(\text{mr}^2 + \text{I}\right)\dot{\theta}^2$

and

Total Potential energy,

$\text{P.E.} = \frac{1}{2}\text{kx}^2 = \frac{1}{2}\text{k}\left(\text{r}\theta\right)^2$

Total Energy of the system, P.E. + K.E. = constant

$\frac{1}{2}\left(\text{mr}^2 + \text{I}\right)\dot{\theta}^2 + \frac{1}{2}\text{kr}^2\theta^2 = \text{C}$ ----------(1)

Differentiating with respect to time equation (1)

$\frac{1}{2}\left(\text{mr}^2 + \text{I}\right)\left(2\dot{\theta}\right)\ddot{\theta} + \frac{1}{2}\left(\text{kr}^2\right)\left(2\theta\right)\dot{\theta} = 0$

$\left\{\left(\text{mr}^2 + \text{I}\right)\ddot{\theta} + \left(\text{kr}^2\right)\theta\right\}\dot{\theta} = 0$

As $\dot{\theta} \neq 0$ at all times, thus

$\left(\text{mr}^2 + \text{I}\right)\ddot{\theta} + \left(\text{kr}^2\right)\theta = 0$

$\omega_\text{n} = \sqrt{\frac{\text{kr}^2}{\text{mr}^2+\text{I}}}$

Assuming $\text{I} = \frac{1}{2}\text{Mr}^2$

$\omega_n = \sqrt{\frac{\text{k}}{\text{m}+\text{M}/2}} = \sqrt{\frac{2k}{2m+M}}$

Q47 **Text Solution:**

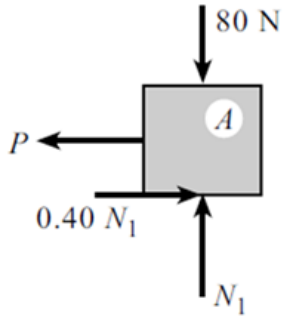
There are three possible cases of motion of the blocks –

(i) Block A has impending motion and blocks B and C remain intact with each other and surface.

(ii) Blocks A and B together have impending motion and block C remains intact with surface.

(iii) All the three blocks A, B and C together have impending motion.

Case (i) :



$\Sigma\text{F}_\text{y} = 0$

$\Rightarrow \text{N}_1 - 80 = 0$

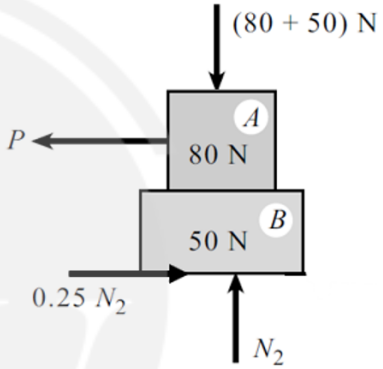
$\Rightarrow \text{N}_1 = 80\ \text{N}$

$\Sigma\text{F}_\text{x} = 0$

$\Rightarrow 0.4\text{N}_1 - \text{P} = 0$

$\Rightarrow \text{P} = 0.4 \times 80 = 32\ \text{N}\ (\leftarrow)$

Case (ii) :



$\Sigma\text{F}_\text{y} = 0$

$\Rightarrow \text{N}_2 - (80 + 50) = 0$

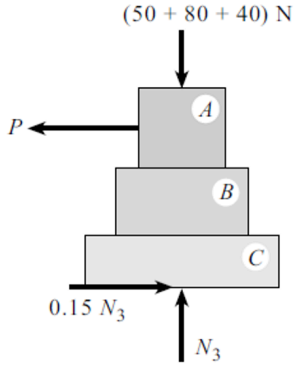
$\Rightarrow \text{N}_2 = 130\ \text{N}$

$\Sigma\text{F}_\text{x} = 0$

$\Rightarrow 0.25\text{N}_2 - \text{P} = 0$

$\Rightarrow \text{P} = 0.25 \times 130 = 32.5\ \text{N}\ (\leftarrow)$

Case (iii) :



$\Sigma\text{F}_\text{y} = 0$

$\Rightarrow \text{N}_3 - (50 + 80 + 40) = 0$

$\Rightarrow \text{N}_3 = 170\ \text{N}$

$\Sigma F_x = 0$

$\Rightarrow 0.15N_3 - P = 0$

$\Rightarrow P = 0.15 \times 170 = 25.5\ N\ (\leftarrow)$

Comparing all three cases, we conclude that P_{max} = 25.5 N before any slipping takes place.

Q48 Text Solution:

α = 5°/step

n_s = 360/5 = 72 step angles

Pitch p = 6 mm/rev

x = 300 mm at v = 40 mm/sec

Number of revolutions = 300/6 = 50 revolutions of the motor shaft

N = (40 mm/sec) (60 sec/min) (1 rev/6 mm) = 400 rev/min = 6.667 rev/sec

(a) A_m = (50 rev) (360°/rev) = 18,000°

n_p = 18,000°/5° = 3600 pulses

(b) $f_P = Nn_s/60 = 6.667(72) = 480$ Hz

Q49 Text Solution:

- A. PERT analysis has three times estimation is TRUE
  PERT uses three time estimates for each activity:
  - Optimistic time (to)
  - Most likely time (tm)
  - Pessimistic time (tp)
    This makes PERT a probabilistic technique.
- B. One time estimate is required for any activity in developing CPM network is TRUE
  CPM assumes a single (deterministic) time estimate for each activity.
- C. Three time estimate is required for any activity in developing CPM network is FALSE
  Three-time estimates are used in PERT, not CPM.
- D. PERT has deterministic technique is FALSE
  PERT is probabilistic, whereas CPM is deterministic.

Q50 Text Solution:

$x^3 - 5x + 3 = 0$

As sum of the root is $\left(\frac{-b}{a}\right)$

So, $a + b + c = \frac{0}{1} = 0$

$\because \begin{vmatrix} a & b & c \\ b & c & a \\ c & a & b \end{vmatrix}$

$c_1 \rightarrow c_1 + c_2 + c_3$

$$\Rightarrow \begin{vmatrix} a+b+c & b & c \\ a+b+c & c & a \\ a+b+c & a & b \end{vmatrix}$$

$$\Rightarrow \left(a+b+c\right)\begin{vmatrix} 1 & b & c \\ 1 & c & a \\ 1 & a & b \end{vmatrix}$$

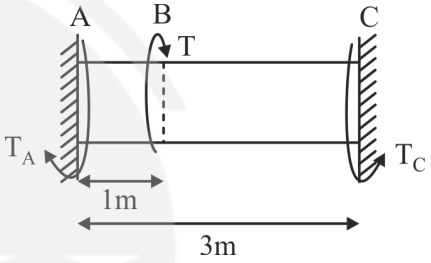
$\Rightarrow 0$

Q51 Text Solution:

D=80 mm

$\tau_p = 80MPa$

T = ?



Torsional moment resistance of AB,

$T_{AB} = T_A$

Torsional moment resistance of BC,

$T_{BC} = T_A - T$

Now,

$\theta_{AC} = 0$

$\Rightarrow \theta_{AB} + \theta_{BC} = 0$

$\frac{1}{GJ}\left[\frac{T_A \times 1000}{1} + \frac{(T_A - T) \times 2000}{1}\right] = 0$

$\Rightarrow T_A + (T_A - T) \times 2 = 0$

$\Rightarrow 3T_A - 2T = 0$

$\Rightarrow T_A = \frac{2T}{3}$

Therefore

$T_{AB} = T_A = \frac{2T}{3}$

$T_{BC} = T_A - T = \frac{2T}{3} - T = -\frac{T}{3}$

$T_{max} = \max\left[\left|\frac{2T}{3}\right|, \left|-\frac{T}{3}\right|\right] = \frac{2T}{3}$

Maximum shear stress (τ_{max}),

$\tau_{max} = \frac{16T_{max}}{\pi D^3}$

$\Rightarrow \tau_{max} = \frac{16 \times \frac{2T}{3}}{\pi \times 80^3}$

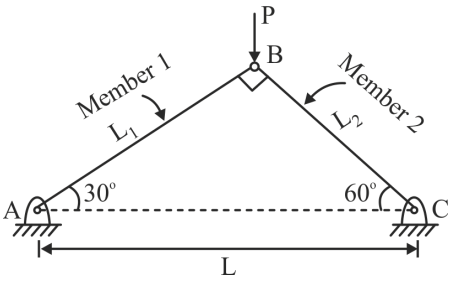
Now at limiting value, $\tau_{max} = \tau_p$

$$\frac{16\times\frac{2T}{3}}{\pi\times 80^3} = 80$$

$$\Rightarrow T = 12.064 \times 10^6\ Nm$$

$$\Rightarrow T = 12.064\ kNm$$

Q52 Text Solution:



from △ABC

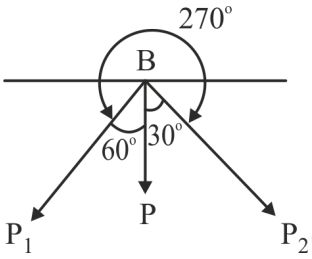
$$\frac{L_1}{\sin 60} = \frac{L_2}{\sin 30} = \frac{L}{\sin 90}$$

$$\Rightarrow L_1 = \frac{\sqrt{3}L}{2}$$

and

$$L_2 = \frac{L}{2}$$

FBD of Joint B,



$$\frac{P_1}{\text{Sin30}} = \frac{P_2}{\text{Sin60}} = \frac{P}{\text{Sin270}}$$

$$\Rightarrow P_1 = -\frac{P}{2} = \frac{P}{2}(\text{compressive})$$

and $P_2 = -\frac{\sqrt{3}P}{2} = \frac{\sqrt{3}P}{2}$ (compressive)

Both members AB and BC are in compression.

To avoid buckling in member AB:

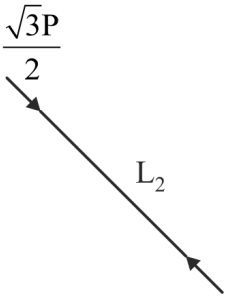
$$Le_1 = L_1 = \frac{\sqrt{3}L}{2}$$

$$\frac{P}{2} \le \left(\frac{\pi^2 EI}{Le_1^2}\right)$$

$$\Rightarrow \frac{P}{2} \le \frac{\pi^2 EI}{\left(\frac{\sqrt{3}L}{2}\right)^2}$$

$$\Rightarrow P \le \frac{8\pi^2 EI}{3L^2}$$

To avoid buckling in member BC



$$Le_2 = L_2 = \frac{L}{2}$$

$$\frac{\sqrt{3}P}{2} \le \frac{\pi^2 EI}{(Le_2)^2}$$

$$\Rightarrow \frac{\sqrt{3}P}{2} \le \frac{\pi^2 EI}{\left(\frac{L}{2}\right)^2}$$

$$\Rightarrow P \le \frac{8\pi^2 EI}{\sqrt{3}L^2}$$

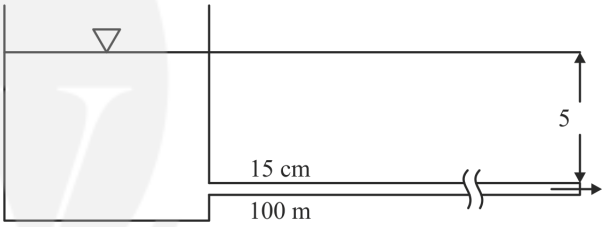
To avoid buckling in the truss member

$$P \le \min\left[\frac{8\pi^2 EI}{3L^2}, \frac{8\pi^2 EI}{\sqrt{3}L^2}\right]$$

$$P \le \frac{8\pi^2 EI}{3L^2}$$

Hence, the maximum allowable value of load P is $\frac{8\pi^2 EI}{3L^2}$

Q53 Text Solution:



Minor losses are:

Entrance loss $= 0.5 \times \frac{V^2}{2g}$ and

Exit loss $= V^2/2g$

Friction loss, $h_f = \frac{fl}{d} \times \frac{V^2}{2g}$

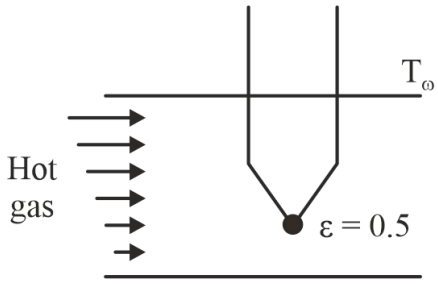
$$H = h_f + 0.5\frac{V^2}{2g} + \frac{V^2}{2g}$$

$$5 = \left[\frac{0.01\times 100}{0.15}\frac{V^2}{2\times 9.81}\right] + \frac{0.5V^2}{2\times 9.81} + \frac{V^2}{2\times 9.81}$$

V = 3.466 m/s

$Q = 3.466 \times \frac{\pi}{4}(0.15)^2 = 0.061$ m³/s = 61 lt/sec

Q54 Text Solution:



$T_{th} = 600^\circ C,\ T_a = 720^\circ C,\ T_w = ?$

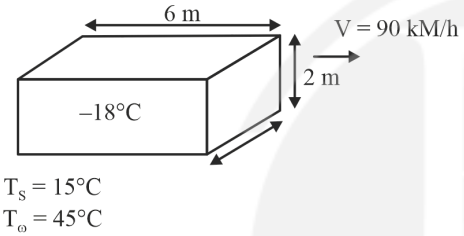
At steady state,

$$hA\left(T_a - T_{th}\right) = A\varepsilon\sigma\left(T_{th}^4 - T_w^4\right)$$

$$60\left(720 - 600\right) = 0.5 \times 5.67 \times 10^{-8}\left(873^4 - T_w^4\right)$$

$$T_w = 756.126\ K = 483.126^\circ C$$

Q55 Text Solution:



$T_s = 15^\circ C$
$T_\omega = 45^\circ C$

$$V = \frac{90\times1000}{3600} = 25\ m/s$$

$$Re = \frac{\rho VL}{\mu} = \frac{1.1514\times25\times6}{1.86\times10^{-5}}$$

$$Re = 9.2854 \times 10^6$$

$$Pr = \frac{\mu C_p}{k} = \frac{1.86\times10^{-5}\times1.007\times10^3}{0.0265}$$

$$Pr = 0.7068$$

$$Nu = 0.036\ Re^{0.8}\ Pr^{0.33}$$

$$\frac{h\times L}{k} = 0.036\left(9.2854 \times 10^6\right)^{0.8}\left(0.7068\right)^{0.33}$$

$$\boxed{h = 53.199\ W/m^2K}$$

$$\dot{Q} = hA\Delta T$$

$$A = 2 \times [6 \times 3 + 6 \times 2]$$

$$A = 60\ m^2$$

$$\dot{Q} = 53.199 \times 60 \times \left(45 - 15\right)$$

$$\dot{Q} = 95.758\ kW$$

Q56 Text Solution:

$$S = \frac{1}{2} - \frac{1}{6} + \frac{1}{24} - \frac{1}{120} + \ldots..$$

$$= \frac{1}{2!} - \frac{1}{3!} + \frac{1}{4!} - \frac{1}{5!} + \ldots$$

$$= 1 - \frac{1}{1!} + \frac{1}{2!} - \frac{1}{3!} + \frac{1}{4!} - \frac{1}{5!} + \ldots$$

$$= e^{-x}|_{x=1} = e^{-1} = 0.3678 \approx 0.368$$

Q57 Text Solution:

$$r = \frac{t_1}{t_2} = \frac{0.10}{0.20} = 0.5$$

Shear angle:

$$\tan\phi = \frac{r\cos\alpha}{1 - r\sin\alpha} \Rightarrow \phi = \tan^{-1}\left(\frac{0.5\cos15^\circ}{1 - 0.5\sin15^\circ}\right)$$

$$= 29.019^\circ$$

Shear force:

$$F_s = F_c\cos\phi - F_t\sin\phi = 500\cos29.019^\circ - 200\sin29.019^\circ = 340.206\ N$$

Shear velocity:

$$V_s = \frac{V\cos\alpha}{\cos(\phi - \alpha)} = \frac{2\cos15^\circ}{\cos(29.019^\circ - 15^\circ)} = 1.991\ m/s$$

Total power:

$$P_{total} = F_c V = 500 \times 2 = 1000\ W$$

Shear power:

$$P_s = F_s V_s = 340.206 \times 1.991 = 677.405\ W$$

Percentage energy in shear plane:

$$\% = \frac{P_s}{P_{total}} \times 100 = \frac{677.405}{1000} \times 100 = 67.74\%$$

Q58 Text Solution:

Given:

x + y + 5z = 3

x + 2y + 2z = 5

2x + 4y + 4z = k

A X= B

$$[A|B] = \begin{bmatrix} 1 & 1 & 5 & 3 \\ 1 & 2 & 2 & 5 \\ 2 & 4 & 4 & k \end{bmatrix}$$

For the system to have infinitely many solutions,

Rank(A) = Rank(A|B) < 3

⇒ All 3 × 3 minors of [A|B] should be zero.

∴ consider a 3 × 3 minor of [A|B]

$$\Rightarrow \begin{vmatrix} 1 & 5 & 3 \\ 2 & 2 & 5 \\ 4 & 4 & k \end{vmatrix} = 0$$

⇒ 1(2k – 20) – 5(2k – 20) + 3 (0) = 0

⇒ 2k – 20 = 0

⇒ k = 10

Q59 Text Solution:

The deviation and cumulative deviation have already been computed above.

$$\text{MAD} = \frac{\sum |\text{actual} - \text{forecast}|}{n}$$

$$= \frac{7+5+18+0+28+12}{6} = 11.7$$

Tracking signal

$$= \frac{\text{cumulative deviation}}{\text{MAD}} = \frac{-24}{11.7} = -2.05$$

Q60 Text Solution:

Given data:

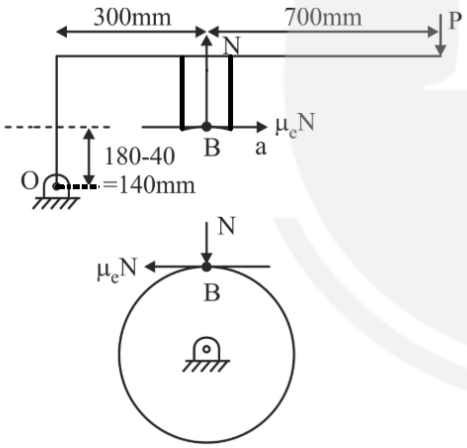
Coefficient of friction, $\mu = 0.25$

Braking torque, $T_B = 300$ Nm

Radius of drum, r =180 mm= 0.18

For Short Shoe, $\mu_e = \mu = 0.25$

When, Brake is self energizing



- To ensure self energizing, the direction of moment of braking effort P about fulcrum and moment of friction force about fulcrum should be same direction in FBD of lever.
- Since moment of braking effort P about fulcrum is clockwise, therefore moment friction force about fulcrum should also be clockwise direction in FBD of lever.
- To ensure this, friction force ($\mu_e N$) should be toward arrows as shown in FBD of lever.

Now, in FBD of lever

$\Sigma M_0 = 0$

$\Rightarrow P \times 1000 - N \times 300 + \mu N \times 140 = 0$

$\Rightarrow P = \frac{N \times 300 - \mu N \times 140}{1000}$

$\Rightarrow P = \frac{N \times 300 - (0.25 \times N \times 40)}{1000}$ ..... (i)

Braking torque,

$T_B = \mu N r$

$300 = 0.25 \times N \times 0.18$

$\Rightarrow N = 6666.667\ N$

Put value of N in equation (i)

$P = \frac{(6666.667 \times 300) - (0.25 \times 6666.667 \times 40)}{1000}$

$\Rightarrow P = 1933.333\ N$

Q61 Text Solution:

$\tau^* = \frac{\rho \forall c}{hA} = \frac{\rho c}{h} \times \frac{h}{6} = \frac{7800 \times 460}{20} \times \frac{0.01}{6}$

$= 299$ sec

$\frac{T - T_\infty}{T_i - T_\infty} = e^{-t/\tau^*} \Rightarrow \frac{T-30}{900-30} = e^{-\frac{30}{299}} \Rightarrow T$

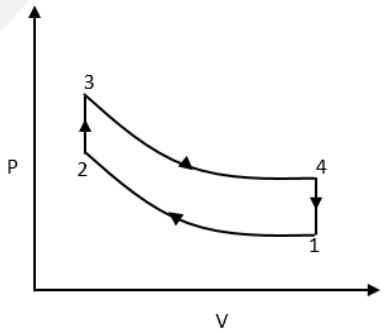
$= 816.945^\circ C$

$\dot{Q}_i = hA\left[T - T_\infty\right] = 20 \times 4\pi\left(0.005\right)^2$

$\times \left(816.945 - 30\right)$

$\boxed{\dot{Q}_i = 4.9445 \text{ watt}}$

Q62 Text Solution:



$v_2 = 0.17\,(v_1 - v_2)$

$1.17 v_2 = 0.17 v_1$

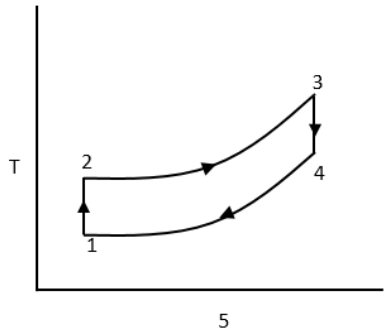
$\therefore \frac{v_1}{v_2} = r_c = \frac{1.17}{0.17} = 6.88$

$\eta_a = 1 - \frac{1}{(r_c)^{\gamma-1}} = 0.5377 = 53.8\%$

The maximum temperature in the cycle is

$\frac{T_2}{T_1} = (r_c)^{\gamma-1}$, $T_2 = (6.88)^{0.4} \times 303$

$= 655.357\ K$



$\frac{P_2}{P_1} = (r_c)^{\gamma}$, $P_2 = (6.88)^{1.4} \times 0.95$

$= 14.1366\ bar$

In a constant pressure process 2-3

$\frac{T_3}{T_2} = \frac{P_3}{P_2}$,

$T_3 = \frac{28}{14.1366} \times 655.357 = 1298.04\ K$

Q63 Text Solution:

Given:

$L^{-1}\left\{\frac{s+3}{s^2-4s+13}\right\} = e^{2t} \cdot \cos 3t + \alpha \cdot e^{2t} \cdot \sin 3t$

$\Rightarrow \frac{s+3}{s^2-4s+13} = L\left\{e^{2t} \cdot \cos 3t\right\} + \alpha \cdot L\left\{e^{2t} \cdot \sin 3t\right\}$

$\because L\{\sin\ at\} = \frac{a}{s^2+a^2}$

$\Rightarrow L\left\{e^{bt} \cdot \sin\ at\right\} = \frac{a}{(s-b)^2+a^2}$

Similarly

$L\left\{e^{bt} \cdot \cos\ at\right\} = \frac{s-b}{(s-b)^2+a^2}$

$\therefore \frac{s+3}{(s-2)^2+9} = \frac{s-2}{(s-2)^2+9} + \frac{\alpha \cdot (3)}{(s-2)^2+9}$

$\Rightarrow \frac{s+3}{(s-2)^2+9} = \frac{s+(3\alpha-2)}{(s-2)^2+9}$

$\Rightarrow 3 = 3\alpha - 2$

$\Rightarrow \alpha = \frac{5}{3} = 1.667$

$\therefore \alpha = 1.667$

Q64 Text Solution:

Given data:

Speed, N = 120 rpm

Stroke length, S = 600 mm

Crank radius, r = $\frac{S}{2} = \frac{600}{2}$ mm = 300 mm

Obliquity ratio, $n = \frac{l}{r} = \frac{1500}{\left(\frac{600}{2}\right)} = 5$

Rotational Speed, $\omega = \frac{2\pi \times 120}{60} = 12.56\ rad/s$

Acceleration of piston, $a = r\omega^2\left(\cos\theta + \frac{\cos 2\theta}{n}\right)$

Acceleration of piston,

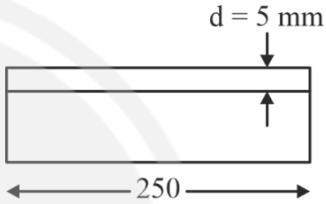
$a = 0.3 \times 12.56^2\left[\cos 30^\circ + \frac{\cos 60^\circ}{5}\right]$

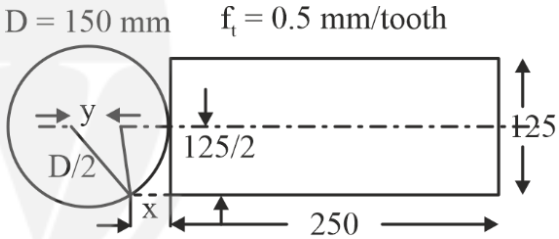
Acceleration of piston, $a = 45.72\ m/s^2$

Inertia force, $F_i = -ma$

$F_i = -250 \times 45.72$ = -11429.54 N = -11.429 kN

Q65 Text Solution:





Machining time = $\frac{L}{fN}$

$\left(\frac{D}{2}\right)^2 = y^2 + \left(\frac{125}{2}\right)^2$

$\Rightarrow \left(\frac{150}{2}\right)^2 = y^2 + \left(\frac{125}{2}\right)^2$

y = 41.457 mm

$\because x = \frac{D}{2} - y\ ;\ x = \frac{150}{2} - 41.457$

x = 33.54 mm

l = 250 + x = 250 + 33.54 = 283.54 mm

f = feed (mm/rev) = $f_t \times \eta_t$ = 0.5 × 8 = 4 mm/rev

V = πDN

4000 mm/s = π × 150 × N

N = 8.48 rev/sec

$T = \frac{L}{fN} = 8.359\ sec$

MRR = Wdf_1

$f_1 = f \times N$

$= 4 \times 8.48 = 33.92$ mm/s

$\therefore$ MRR $= 125 \times 5 \times 33.92$

$= 21200$ mm^3/s