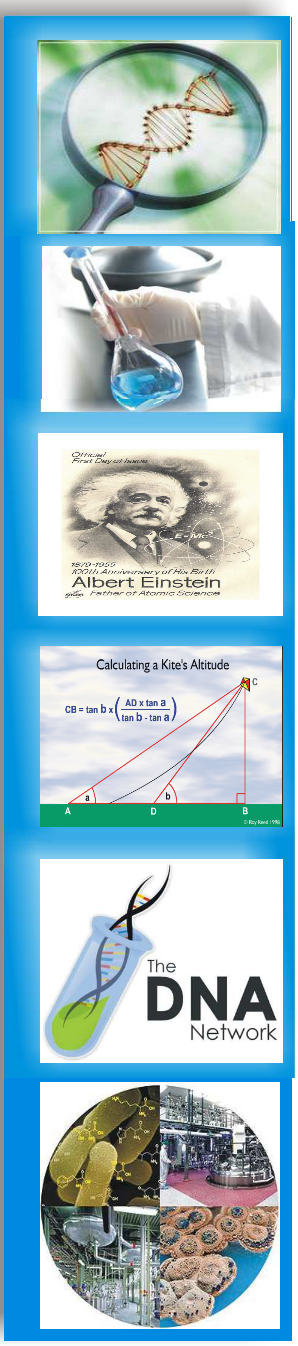

GATE - MECHANICAL ENGINEERING

MOCK TEST PAPER

- *There are a total of 65 questions carrying 100 marks.*
- *Questions (1-25) will carry 1-mark each and questions (26-55) will carry 2-marks each.*
- *Questions (56-65) belongs to general aptitude (GA). Questions (56-60) will carry 1-mark each, and question (61-65) will carry 2-marks each*
- *For Q.1-25 and Q.56-60 1/3 mark will be deducted for each wrong answer.For Q.26-51 and Q. 61-65 2/3 mark will be deducted for each wrong answer. The question pairs (Q.52, Q.53) and (Q.54, Q.55) are linked questions.For Q.52 &54 2/3 mark will be deducted. There is no negative marking for Q.53 &Q.55.*
- *Q.48-51 are common data questions. If first question is attempted wrongly then answer of second question will not be evaluated.*
- *Pattern of questions : MCQs & Numerical*
- *Total marks : 100*
- *Duration of test : 3 Hours*

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Q 1-25 (1 MARK EACH)

1. A second order system starts with an initial condition of $\begin{bmatrix} 2 \\ 3 \end{bmatrix}$ without any external input. The state transition matrix for the system is given of 1 second is given by

(A) $\begin{bmatrix} 0.271 \\ 1.100 \end{bmatrix}$

(B) $\begin{bmatrix} 0.135 \\ 0.368 \end{bmatrix}$

(C) $\begin{bmatrix} 0.271 \\ 0.736 \end{bmatrix}$

(D) $\begin{bmatrix} 0.135 \\ 1.100 \end{bmatrix}$

2. A triangle ABC consists of vertex points

A(0, 0) B(1, 0) and C(0, 1)

Value of integral $\iint 2x\, dx\, dy$ over the triangle is

(A) 1

(B) $\frac{1}{3}$

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

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

3. Singular solution of p = log (px – y) is

(A) y = x(log x–1)

(B) y = x log x – 1

(C) y = log x – 1

(D) y = x log x

4. If $u = x^3 + 3xy^2 + 3x^2 + 1$, then analytic function f(z) = u(x, y) + iv (x, y) is

(A) $3xy - y^3 + 6xy^2 + C$

(B) $3x^2y - y^3 + 6xy + C$

(C) $3x^2y^2 - y^3 + 6xy + C$

(D) $3x^2y - y^3 + 6xy^2 + C$

5. If two lines of regression are Y = 3x – 5 and Y = 2x – 4, then □(X, Y) is equal to

(A) $\sqrt{\frac{2}{3}}$

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

(C) $\sqrt{\frac{3}{2}}$

(D) none of these

6. The probability that two friends share the same birth-month is

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

(B) $\frac{1}{12}$

(C) $\frac{1}{144}$

(D) $\frac{1}{24}$

7. The value of $\oint \frac{z-3}{z^2+2z+5} dz$ for | z | = 1, where C is the circle, is __________.

8. A particle starts from rest with a constant acceleration □ in/ sec^2 and after some time it decelerates at a uniform rate of □ m/sec^2 till it comes to rest . If the total time taken between two rests positions is t, then maximum velocity acquired by the particle would be

(A) $\frac{\alpha+\beta}{2}t$

(B) $\frac{\alpha-\beta}{2}t$

(C) $\left(\frac{\alpha\beta}{\alpha+\beta}\right)t$

(D) $\left(\frac{\alpha+\beta}{\alpha-\beta}\right)t$

9. Following are the value of a function

y(x): y(–1) = 5, y(0), y (1) = 8

$\frac{dy}{dx}$ at x = 0 as per Newton's central difference scheme is ______________.

10. A wooden sphere of mass 1 kg is suspended on a string which is 1 meter long. A bullet of mass 50 grams is shot at the sphere with a velocity v_0 and becomes embedded in it . Because of the impact, the sphere is raised a distance of 0.2 m above the horizontal. What is V_0 of the bullet ?

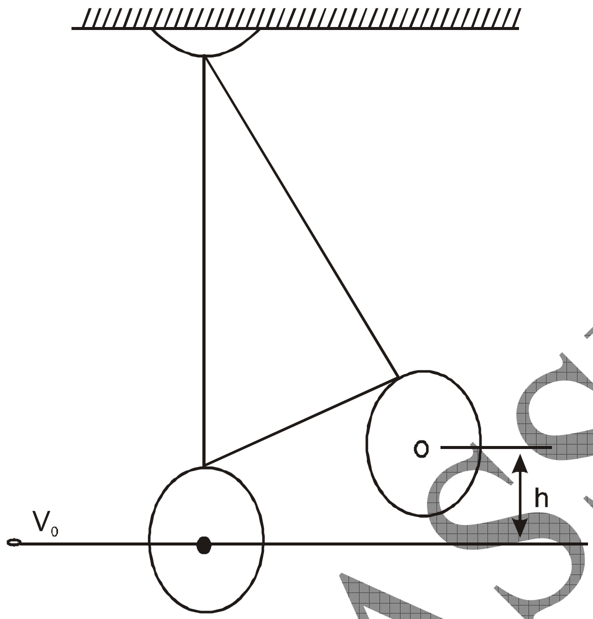
Assume, g = 10 $\frac{m}{sec^2}$

(A) 26m/sec

(B) 35 m/ sec

(C) 42m/sec

(D) 4.2 m/sec



11. Electrochemical machining is performed to remove material from an iron surface of 20 mm × 20 mm under the following conditions:

Inter electrode gap	0.2 mm
Supply voltage	12 V
Specific resistance of electrolyte	2 Ωcm
Atomic weight of Iron	55.85
Valency of Iron	2
Faraday 's constant	96540 Coulombs

The material removal rate (in g/s) is ______________.

12. A hollow circular column of internal diameter 'd' and external diameter ' 1.5 d' is subjected to compressive load. The maximum distance of the point of application of load from the centre for no tension is

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

(B) $\frac{13d}{48}$

(C) $\frac{d}{4}$

(D) $\frac{13d}{96}$

13. Tool life testing on a lat the he under dry cutting conditions gave n and C of Taylor tool equation as 0.12 and 130m/min, respectively. When a coolant was used , C increased by 10 % , the percent increase in tool life with the use of coolant at a cutting speed of 90 m/min will be ___________.

14. A mild steel (ms) block of 20 mm width is being milled using a straight slab milling cutter with 20 teeth, 50 mm diameter, and 10° radial rake. The feed velocity of the table is 15 mm/ min and the cutter rotates at 60 r.p.m . If a depth of cut of 1 mm is used,then the power consumption will be_______.(in Watt)

(□= 0.5, □ = 400 N / mm^2)

15. A shaft has an attached disc at the centre of its length. The disc has its centre of gravity located at a distance of 2 mm from the axis of the shaft. When the shaft is allowed to vibrate in its natural low - shaped mode , it has a frequency of vibration of 10 radians/ second . When the shaft is rotated at 300 revolutions per minute. It will whirl with a radius of

(A) 2mm

(B) 2.25 mm

(C) 2.50 mm

(D) 3.00 mm

16. Determine the minimum value of the basic dynamic load rating for selecting ball bearing to 5000 hrs of operations with not more than 10 percent failures. The radial load is 1800 N during 90 percent. The sheet is rotated at 150 rev/min

(A) 12.45 kN

(B) 25 KN

(C) 13.45 kN

(D) 14.25 kN

17. A body of mass 10 kg moving with a velocity of 1 m/s is acted upon by a force of 50 N for two seconds. The final velocity will be __________.(in m/ sec)

18. A 50 mm diameter solid shaft is welded to a flat plate by 10 mm fillet weld.
The maximum torque that the welded point can sustain if the maximum shear stress intensity in the weld material is not to exceed 80 MPa, is

(A) 2kN - m

(B) 2.1 kN - m

(C) 2.22kN - m

(D) 2.35 kN - m

19. A strip with a cross section 150mm x 6mm is being rolled with 20% reduction of area ,using 400 mm-diameter steel rolls.Before and after rolling, the shear yield stress of the material is 0.35 kN/mm^2 and 0.4kN/mm^2 respectively. Location of the neutral point $\square_n$ will be __________.

20. A 20 cm diameter pipe 5000 meters long conveys 0.05 cumec of water which is to be pumped through a height of 6 meters. The horse power required by the pump, if its efficiency is 75 % (Take 4f = 0.006), will be

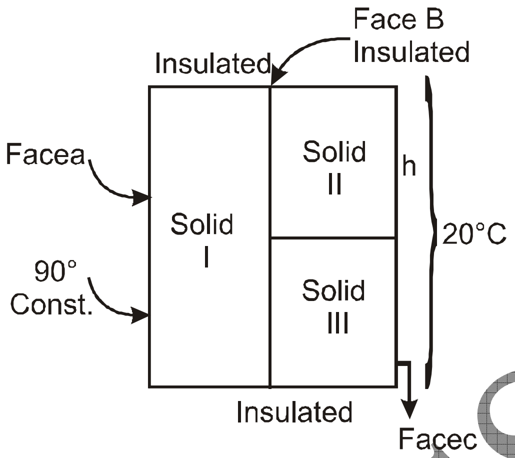
(A) 74.2 HP

(B) 74 HP

(C) 75HP

(D) 50HP

21. For the situation below, what would happen to the average temperature at face C if the thermal conductivity of solid II was increased ?



(A) No change

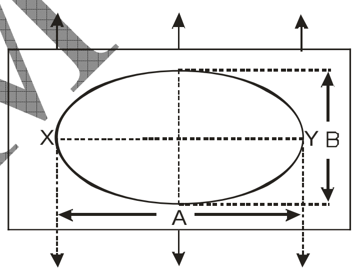
(B) Becomes 20° C

(C) Increase

(D) Decrease

22. The natural frequency of an undamped vibrating system is 100 rad/s. A damper with a damping factor of 0.8 is introduced into the system. The frequency of vibration of the damped system, in rad/ s is __________.

23. A loaded semi - infinite flat plate is having an elliptical hole (A/B = 2) in the middle as shown in the figure. The stress concentration factor at points either x or Y is ___________.



24. A long steel rod, 22 mm in diameter , is to be heated from 693 K to 813 K. It is placed concentrically in a long cylindrical furnace which has an inside diameter of 0.18m. The inner surface of the furnace is at temperature of 1373 K and has an emissivity of 0.82. If we assume C = .67 kJ/kg K and = 7845 kg/m^3 for the steel, the rate of heat absorption when the rod is at 813 K will be

(A) 0150 7447 W/m

(B) –7940 W/m

(C) –8147 W/m

(D) –8347 W/m

25. The engine oil at 150°C is cooled to 80°C in a parallel flow heat exchanger by water entering at 25°C and leaving at 60°C

The number of transfer units will be

(A) 1

(B) 1.2

(C) 1.6

(D) 2.0

Q 26-55 (2 MARKS EACH)

26. For a mixture of solid , liquid and vapour phases of a pure substance , in equilibrium, the number of independent intrinsic properties needed will be

(A) 0

(B) 1

(C) 2

(D) 3

27. A body of weight 100 N falls freely through a distance of 10m against an atmospheric drag force of 5 N. Considering the body as the system , the work interaction is

(A) 1000 Nm

(B) 1050 Nm

(C) 950 Nm

(D) 50 Nm.

28. Initial volume of a closed system is 0.2 m^3. The system is air,initial pressure and temperature are 50 kPa and 90°C. The air is compressed to a final volume of 0.02 m^3 and the final pressure became 2000kPa.

R for air is 0.287 kJ/kgK and C_V = 0.718 kJ/kg°C.

Value of n for the process will be

(A) 1.2

(B) 1.4

(C) 1.6

(D) 1.8

29. The movable wicket gates of a reaction turbine are used to

(A) Control the flow of water passing through the turbine.

(B) Control the pressure under which the turbine is working

(C) Strengthen the casing of the turbine

(D) reduce the size of the turbine.

30. 100cu.m. of air per minute at 30°C DBT and 60% RH is cooled to 20°C DBT by passing through a cooling coil.

The capacity of cooling coil in tons of refrigeration will be

(A) 5.48 ton

(B) 7.48 ton

(C) 7.98 ton

(D) 8.48 ton

31. Which of the following is a copper free alloy ?

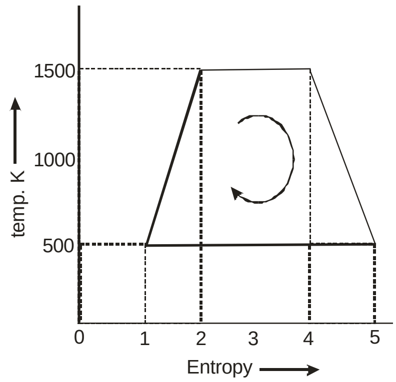
(A) Brass

(B) Phosphor bronze

(C) Invar

(D) Muntz metal

32. The efficiency of a reversible cyclic process undergone by a substance as shown in the given diagram is ______________.



33. For casting aluminium cube of sides 15cm. The volume of shrinkage of Aluminium during solidification is 6.5%. The cylindrical top riser is used

What will be the diameter of cylindrical riser

(A) 18cm

(B) 21cm

(C) 25cm

(D) 24cm

34. Length to radius ratio $\frac{\ell}{r}$ of a solid cylinder such that the moments of inertia about the longitudinal and transverse axes are equal is

(A) 1

(B) $\sqrt{3}$

(C) $\sqrt{5}$

(D) 2

35. A firm produces and used 2400 items annually. The cost of setting up for production rate is 100 units. The production cost is Rs. 5 per item. The annual storage and carrying is 10% of average inventory. The time , each optimum production run would take, will be

(A) 12 months

(B) 9 months

(C) 6 months

(D) 1 month

36. Consider the following Linear Programming Problem (LPP) :

Maximize $z = 3x_1 + 2x_2$

Subject to $x_1 \leq 4$

$x_2 \leq 6$

$3x_1 + 2x_2 \leq 18$

$x_1 \geq 0, \quad x_2 \geq 0$

(A) The LPP has a unique optimal solution.

(B) The LPP is not feasible.

(C) The LPP is unbounded.

(D) The LPP has multiple optimal solution.

37. Match correct pairs between list I and List II for the questions

List I	List II
(a) Hooke's law	1. Planetary motion
(b) St. Venant's law Energy	2. Conservation
(c) Kepler's laws	3. Elasticity
(d) Tresca's criterion	4. Plasticity
(e) Coulomb's laws	5. Fracture
(f) Griffith's law	6. Inertia

(A) (a) 3, (c) 1, (d) 5, (e) 2

(B) (a) 3, (c) 2, (d) 5, (e) 6

(C) (a) 3, (b) 1, (f) 5, (e) 2

(D) None of these

38. A small body at 100° F is placed in a large heating oven whose walls are maintained at 2000 °F. The average absorptivity of the body varies with the temperature of the emitter as follows :

Temperature (°F)	100°F	1000°F	2000°F
Absorptivity, a	0.8	0.6	0.5

What is the rate at which radiant energy is absorbed by the body per unit surface area ? (The Stefan - Bolzmann constant.

□ = 0.1714 × 10^{-8} Btu / hr = ft^2 – R^4).

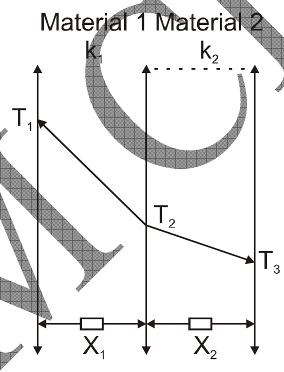
(A) 2.11 × 10^{-4} Btu/hr - ft^2

(B) 3.38 × 10^{-4} Btu/hr - ft^2

(C) 13.7 Btu/hr - ft^2

(D) 3.16 × 10^{-5} Btu/hr - ft^2

39. The temperature drop through each layer of a two-layer furnace wall is shown in the figure. Assume that the external temperatures T_1 and T_3 are maintained constant and that $T_1 > T_3$. If the thicknesses of the layers, x_1 and x_2, are the same, which one of the following statements is correct ?



(A) $k_1 > k_2$, where k is the thermal conductivity of the layer

(B) $k_1 > k_2$

(C) $k_1 = k_2$, but the heat flow through material 1 is larger than the through material 2.

(D) $k_1 = k_2$, but the heat flow through material 1 is less than that through material 2.

40. A wire is plastically deformed (bent) by supplying a force of 40 N over a distance of 0.8 m. (The force moves in the direction in which the distance is measured). If the wire has a mass of 0.2 kg and a specific heat of 0.5 kJ/kg. °C, estimate the maximum increase in the average temperature of the wire

(A) 0.03°C

(B) 0.3°C

(C) 3°C

(D) 30°C

41. A source of radiation has an intensity of 840 watts/m^2. Find the number of photons per second per square meter represented by this intensity, if the wavelength is 500 nm.

(Use speed of light = 3×10^4 m / s, and Plank's constant h = 7×10^{34} J.s.)

(A) 10.4×10^{21}

(B) 6.8×10^{21}

(C) 4.4×10^{21}

(D) 2.2×10^{21}

42. A plate having an area of 1 m^2 is dragged down an inclined plane at 45° to the horizontal with a velocity of 50 cm. There is a cushion of fluid 1 mm thick between the plane and the plate. If the viscosity of the fluid is one poise, the weight of the plate will be

(A) 70 N

(B) 70.7 N

(C) 72 N

(D) 78 N

43. A plate 1 mm distant from a fixed plate moves at 0.25 m/s and requires a force/unit area of one Pascal to maintain this speed. The viscosity of the fluid between the plates will be

(A) 0.4 Ns/m^2

(B) 0.04 Ns/m^2

(C) 0.004 Ns/m^2

(D) 0.0004 Ns/m^2

44. A piston of diameter 60 mm moves inside a cylinder 60.10 mm diameter. The percentage decrease in force necessary to move the piston when the lubricant warms up from 0°C to 120° C, will be

(Values of for the lubricant are 0.01820 Ns/m^2 and 0.00206 Ns/m^2 at 120° C.)

(A) 88.7%

(B) 8.87 %

(C) 98.7%

(D) none of these

45. For laminar flow in a pipe, V is equal to

(A) U_{max}

(B) 0.5 U_{max}

(C) 0.25 U_{max}

(D) 2 U_{max}

46. The relation pV = constant, where is the ratio of the specific heats of ideal gas, is applicable to

(A) any adiabatic process

(B) only reversible adiabatic process

(C) only irreversible adiabatic process

(D) only isothermal process

47. A shaft subjected to a maximum bending stress of 80 N/mm^2 and maximum shearing stress equal to 30 n/mm^2 at a particular section. If the yield point in tension of the material is 280 N/mm^2, and maximum shear stress theory of failure is used, then the factor of safety obtained will be

(A) 2.5

(B) 2.8

(C) 3.0

(D) 3.5

Common Data Ques 48 - 49

A solid shaft is subjected to a torque of 45kNm. The angle of twist is 0.5° meter ,length of the shaft and the shear stress is not to be allowed to exceed $90 MN/m^2$.

48. Diameter of the shaft will be

(A) 140 mm

(B) 160 mm

(C) 150 mm

(D) 170 mm

49. Maximum shear strain in the shaft will be

(A) 6.99×10^{-4}

(B) 6.7×10^{-4}

(D) 6×10^{-4}

(D) 5×10^{-4}

Common Data Ques 50-51

A vertical petrol engine 100 mm diameter and 120 mm stroke has a connecting rod 250 mm long. The mass of the piston is 1.1 kg. The speed is 209.5r.p.m. on the expansion stroke with a crank 20° from the top dead centre, the gas pressure is $700 kN/m^2$.

50. Inertia force on the piston will be

(A) 2254 N

(B) 3254 N

(C) 5264 N

(D) 7784 N

51. Net force on the piston and resultant load on the gudgeon pin will be

(A) 256 N, 2265 N

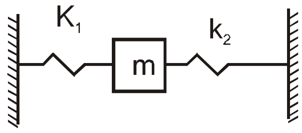
(B) 6551N, 1256 N

(C) 1265 N, 2661 N

(D) 2256N, 2263.9 N

Linked Ans Ques 52, 53

52. For the spring - mass system shown in the figure , the frequency of vibration is N. What will be the frequency when one more similar spring is added in series, as shown in figure ?



(A) N

(B) $\frac{N}{\sqrt{2}}$

(C) $\frac{N}{2\sqrt{2}}$

(D) 2 N

53. The equation of motion of the above system is

(A) $m\ddot{x} + kx = 0$

(B) $\frac{m}{2}\ddot{x} + kx = 0$

(C) $\frac{3m}{2}\ddot{x} + kx = 0$

(D) $2m\ddot{x} + kx = 0$

Linked Ans. Ques. 54-55:

Glycerine (□= 1.50Pa.sand □= 1260 kg/m^3) flows at a velocity of 6.0 m/s in a 20 cm diameter pipe.

54. The head loss in a length of 12m pipe will be

(A) 3m

(B) 4

(C) 6m

(D) 7m

55. Power expanded by the flow in a distance of 12m will be

(A) 12.24 W

(B) 16.24 kW

(C) 20.24 KW

(D) 14.25kW

GENERAL APTITUDE

Q 56-60 (1 MARK EACH)

56. REASON : SFBTPO :: THINK : ?

(A) SGHMJ

(B) UIJOL

(C) UHNKI

(D) UJKPM

57. MORTAL opposite word –

(A) Divine

(B) Immortal

(C) Spiritual

(D) Eternal

58. ALERT similar word –

(A) Energetic

(B) Observant

(C) Intelligent

(D) Watchful

59. A shopkeeper expects a gain of 22.5% on his cost price. If in a week, his sale was of Rs. 392, what was his profit?

(A) Rs. 18.20

(B) Rs. 70

(C) Rs. 72

(D) Rs. 88.25

60. IF '+' stands for '-' , '-' stands for 'x', 'x' stands for '÷'and '÷'stands for '+'then what is the value of 56x7÷13-11+15-8÷2-7?

(A) 30

(B) 45

(C) 60

(D) 90

Q 61-65 (2 MARKS EACH)

61. 'Captain' is related to 'Soldier' in the same way as 'Leader' is related to

(A) Chair

(B) Followers

(C) Party

(D) Minister

62. PORK:PIG

(A) rooster:chicken

(B) mutton:sheep

(C) steer:beef

(D) lobster:crustacean

63. My uncle decided to take ...... and my sister to the market.

(A) I

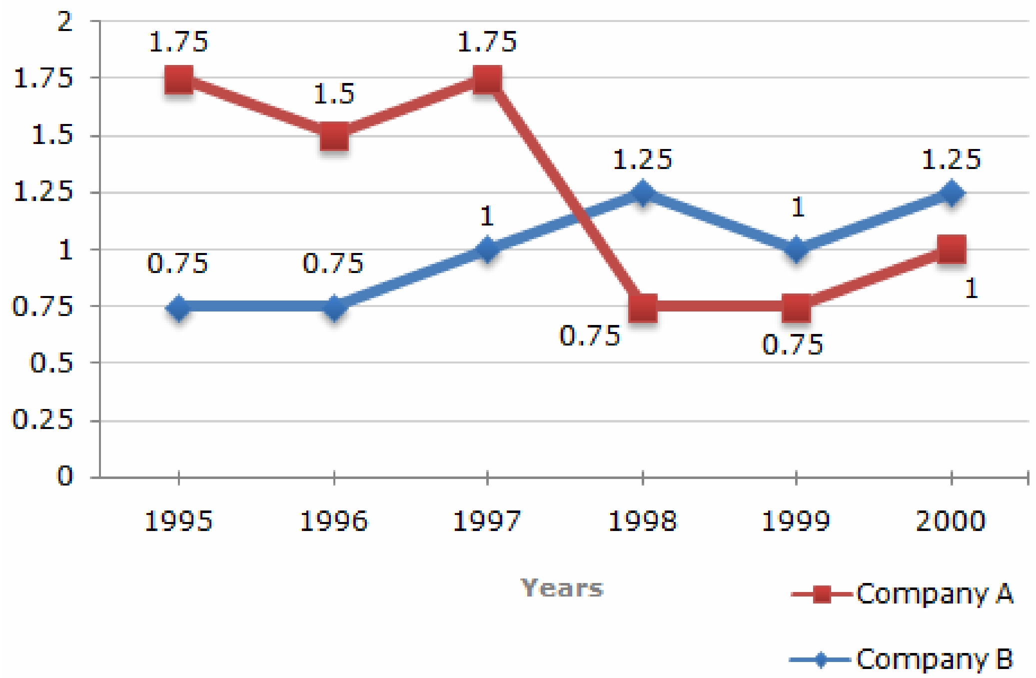
(B) mine

(C) me

(D) myself

64. Answer the question based on the given line graph.

Ratio of Exports to Imports (in terms of money in Rs. crores) of Two Companies Over the Years



In how many of the given years were the exports more than the imports for Company A?

(A) 2

(B) 3

(C) 4

(D) 5

65. Look at this series: 58, 52, 46, 40, 34, ... What number should come next?

(A)26

(B)28

(C) 30

(D) 32

Answer key

Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Answer	A	B	A	B	A	B	0	C	1.5	D	0.3471	B	122%	60	B	A	11	C	0.023	A
Question	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Answer	C	60	7	A	B	A	D	C	B	B	C	0.66	A	B	B	D	A	D	B	B
Question	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
Answer	D	B	C	A	B	B	B	B	A	B	D	B	C	D	B	B	B	D	C	B
Question	**61**	**62**	**63**	**64**	**65**															
Answer	B	B	C	B	B															

HINTS AND SOLUTIONS

1.(A) The state of the system at time t is.

$$X(t) = [sI - A]^{-1}X(0) = \square(t)X(0)$$

$$= \begin{bmatrix} e^{-2t} & 0 \\ 0 & e^{-t} \end{bmatrix}\begin{bmatrix} 2 \\ 3 \end{bmatrix} = \begin{bmatrix} 2e^{-2t} \\ 3e^{-t} \end{bmatrix}$$

At $t = 1$, $X(1) = \begin{bmatrix} 2e^{-2} \\ 3e^{-1} \end{bmatrix} = \begin{bmatrix} 0.271 \\ 1.100 \end{bmatrix}$

2.(B) Equation of the straight line joining (1, 0) and (1, 0) is

$$x + y = 1, \qquad y = 1 - x$$

Consider $\iint 2x\,dx\,dy = \int 2x\,dx \int_0^{1-x} dy$

$$= \int 2x\,dx\,(y)_0^{1-x}$$

$$= \int 2x\,dx\,(y)_0^{1-x}$$

$$= \int (2x - 2x^2)\,dx$$

Since, limits of the integral are now between 0 and 1

$$\therefore \quad \iint 2x\,dx\,dy = \int_0^1 \left(2x - 2x^2\right)dx$$

$$= \left[x^2 - \frac{2x^3}{3}\right]_0^1 = 1 - \frac{2}{3} = \frac{1}{3}$$

3.(A) Given differential equation is

$$p = \log(px - y)$$

$$\therefore \quad y = px - e^p \qquad \text{....(i)}$$

This equation is of the form of Clairaut's equation. General solution of this equation is

$$y = cx - e^c \qquad \text{....(ii)}$$

Differentiating equation (ii) with respect to c, we get

$$0 = x - e^c$$

$$\therefore \quad x = e^c$$

$$\therefore \quad c = \log x \qquad \text{....(iii)}$$

Eliminating c between equations (ii) and (iii), required singular solution is

$$y = x \log x - x = x(\log x - 1)$$

4.(B) Given: $u = x^3 - 3xy^2 + 3x^2 - 3y^2 + 1$

$$\therefore \quad \frac{\partial u}{\partial x} = 3x^2 - 3y^2 - 3y^2 + 6x$$

and $\frac{\partial u}{\partial y} = -6xy - 6y$

By C.R. equations,

$$\frac{\partial u}{\partial x} = 3x^2 - 3y^2 + 6x$$

$$\therefore \quad V = 3x^2y - y^3 + 6xy + \phi(x) + C \qquad \text{.....(i)}$$

5.(A) If we take y = 3x – 5 regression equation of Y on X and Y = 2x – 4 as that of X on Y, then

$$b_{yx} = 3 \; b_{xy} = \frac{1}{2}$$

□ $b_{yx}\, b_{xy} = \frac{3}{2}$, which is not possible.

Hence, equation y = 3x – 5, i.e. x = is then regression equation of X on Y and equation, Y = 2x – 4 is that Y on X.

Then $b_{yx} = 2$ and $b_{xy} = \frac{1}{3}$

□ $b_{xy}\, b_{xy} = \frac{3}{2}$

□ $\{□(X, Y)\}^2 = \frac{3}{2}$

□ $□(XY) = \sqrt{\frac{2}{3}}$

6.(B) Probability that first friend is born in any month

= 100% = 1

probability that second friend is born in the same moth as that of first friend

$= 1 \times \frac{1}{12} = \frac{1}{12}$

7. ˜

Poles of $f(z) = \frac{z-3}{z^2+2z+5}$ are given by

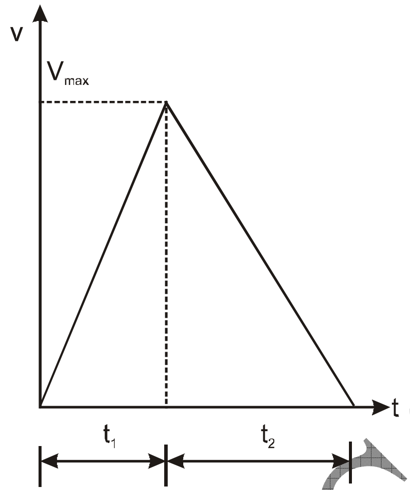
$z^2 + 2z + 5 = 0$

□ $z = \frac{-2 \pm 4i}{2} = -1 \pm 2i$

Since, both poles lie outside the circle | z | = 1, therefore f(z) is analytic inside the circle

□ $\oint \frac{z-3}{z^2+2z+5} dz = 0$

8.(C) From v = u + at



$t_1 = \frac{\upsilon_{max}}{\alpha}$ and $t_2 = \frac{\upsilon_{max}}{\beta}$

□ $t = t_1 + t_2$

$= \frac{\upsilon_{max}}{\alpha} + \frac{\upsilon_{max}}{\beta} = \upsilon_{max}\left(\frac{\alpha+\beta}{\alpha\beta}\right)$

□ $= \upsilon_{max} = \frac{\alpha\beta}{a+\beta} t$

9. 1.5

$\left(\frac{dy}{dx}\right)_{at\,x=0} = \frac{y_2 - y_1}{x_2 - x_1}$

$= \frac{y(1) - y(-1)}{1-(-1)} = \frac{8-5}{2} = 1.5$

10.(D) Such a set up is called ballistic pendulum. This problem can be solved using energy conservation principle. Since it is an inelastic collision.

From conservation of momentum

$m_1 V_0 = (m_1 + m_2)V$

or $V = \frac{m_1 V_0}{(m_1 + m_2)}$ ....(i)

From energy conservation

$$\frac{1}{2}(m_1+m_2)V^2=(m_1+m_2)gh$$

or $V^2 = 2gh$

Now $\frac{m_1^2V_0^2}{(m_1+m_2)^2}=2gh$

 $V_0^2=\frac{2gh\times(m_1+m_2)^2}{m_1^2}$

$=\frac{2\times10\times0.2\times(1.050)^2}{.05\times.05}$

= 4.2m/sec

11. 0.3471

Since R = $\frac{\rho l}{A}$

Since resistance of electrolyte = 2 cm,

l = interelectrode gap = 0.2 mm

A = cross sectional area of electrode = 20 × 20 mm^2

R = (2 × 10) × $\frac{0.2}{20\times20}$ = 0.01

I = $\frac{V}{R}=\frac{12}{0.01}$ = 1200 A

As per Faraday law E = $\frac{M}{v}$, E = equivalent weight,

M = molecular weight, = valency

Metal Removal Rate (gm/sec)

$=\frac{I}{M}\times\frac{M}{v}=\frac{1200}{96540}\times\frac{55.85}{2}=0.3471$

12.(B) For hollow circular column. to avoid tension eccentricity ,

$$e=\frac{D^2+d^2}{8D}$$

where , D = external diameter

= 1.5 d

d = internal diameter

$$e = \frac{(15d)^2 + (d)^2}{8 \times 15 \times d}$$

$$= \frac{3.25d^2}{12d} = \frac{13}{48}d$$

13. **122%**

Given : Initially n = 0.12 , C_1 = 130 m/ min

After a coolant is used ,

C_2 = 130 × 1.1 = 143 m/ min

using Taylor equation

$VT^n = C$

or $T_1^{0.12} = \frac{130}{90}$

$$\therefore \quad T_1 = \left(\frac{130}{90}\right)^{1/0.12} = 21.42$$

Also, $90 (T_2)^{0.12} = 143$

or $T_2 = \left(\frac{143}{90}\right)^{1/0.12} = 47.54$

$\therefore$ Percent increase in tool life

$$= \frac{T_2 - T_1}{T_1}$$

$$= \frac{47.54 - 21.42}{21.42} \times 100 = 122\%$$

14. **60**

$$\sin\beta = \sqrt{\frac{d}{D}} = 2.\sqrt{\frac{1}{5}} = 0.28284$$

 = 16.4°

Angle between two consecutive teeth

$$= \frac{2\pi}{Z} = \frac{2\pi}{20} = 180° > B$$

Maximum uncut thickness,

$$t_{1\,max} = \frac{2t}{NZ}\sqrt{\frac{d}{D}}$$

$$= \frac{2\times 15}{60\times 20}\sqrt{\frac{1}{50}}$$

= 0.0035 mm

Friction angle, = $\tan^{-1}m$

= $\tan^{-1} 0.5$

= 26.57

Following Lee's and sheffer's shear angle relationship

 = 28.43°

 = 45° + –

= 45 + 10 – 26 .57

$$(F_C)_{max} = \frac{wt_{1max}.t_s \cos(\lambda - \alpha)}{\sin\phi \cos(\phi - \lambda - \alpha)}$$

$$= \frac{20\times 0.0035\times 400\times \cos(26.37° - 10)}{\sin 28.43° \cos\frac{\pi}{4}}$$

= 81.5 N

The variation of torque due to a single tooth with arber rotation is

$$M_{aV} = \frac{1}{2}\times\frac{16.4\times 2}{18} = 0.91N - m$$

Angular speed $= \frac{2\pi\times 60}{60} = 2\pi/\sec$

 Power requirement = 2 × 0.91 W 60 W

15.(B) ω_1 = 10 rad/ sec.

$\omega_2 = \frac{300 \times 2\pi}{60} = 10\pi$

$\therefore$ radius, $y = \frac{e}{\left(\frac{\omega_1}{\omega_2}\right)^2 - 1} = \frac{2}{\left(\frac{1}{\pi}\right)^2 - 1} = 2.25\text{mm}.$

16.(A) Since the bearing is under variable loads , the dynamic load rating is given by the formula.

$$C = \left(\frac{\sum P_i^3 L_i}{10^6}\right) = \left(\frac{L_1P_1^3 + L_2P_2^3}{10^6}\right)^{\frac{1}{3}}$$

where L_1 = 0.9 × 150 × 60 × 5000

= 40.5 × 10 revolutions

L_2 = 0.10 × 150 × 60 × 5000

= 4.5 × 10 revolutions

P_i = 1800 N

P_2 = 7200 N

$$\therefore \quad C = \left[\frac{40.5\times10^6 \times 1800^3 + 4.5\times10^6 \times 7200^3}{10^6}\right]^{\frac{1}{3}}$$

= 12.45kN

17. 11

Velocity = mass × acceleration

$\Rightarrow$ 50 = 10 × a

or a = 5 m/ sec^2

Velocity after 2 seconds,

v = u + at

= 1 + 5 × 2 = 11m/sec

18.(C) Since $\tau_{max} = \frac{2.83T}{\pi \times 10 \times 50^2}$

$\therefore$ $80 = \frac{2.83T}{\pi \times 10 \times 50^2}$

or T = 2.22 kN - m

19. 0.023

Location of the neutral point θ_n is given by

$$\theta_n = \sqrt{\frac{t_f}{R}} \tan \frac{\lambda_n}{2} \sqrt{\frac{t_f}{R}}$$

Where , t_f = 4.8 mm, R= 200 mm

and $\lambda_n = \frac{1}{2}\left[\frac{1}{\mu}\log_e\left(\frac{t_f}{t_i}\right) + \lambda_i\right]$

where , $\lambda_i = 2\sqrt{\frac{R}{t_f}} \tan^{-1}\left[\sqrt{\frac{R}{t_f}}.\theta_i\right]$

$= 2\sqrt{\frac{200}{4.8}} \tan^{-1}\left[\sqrt{\frac{200}{4.8}} x0.0775\right] = 5.99$

$\therefore$ $\lambda_n = \frac{1}{2}\left[\frac{1}{0.1}\log_e\left(\frac{4.8}{6}\right) + 5.99\right]$

= 1.88

$\therefore$ $\theta_n = \sqrt{\frac{4.8}{200}} \tan\left[\frac{1.88}{2}\sqrt{\frac{4.8}{200}}\right] = 0.023$

20.(A) $Z_2 - Z_1$ = 6 metres,

η=75% 4f = 0.006

Loss of head in the pipe line,

$h_f = \frac{4f.\ell.Q^2}{3.0257d^5} = \frac{0.006 \times 5000 \times 0.05^2}{3.0257(0.2)^5}$

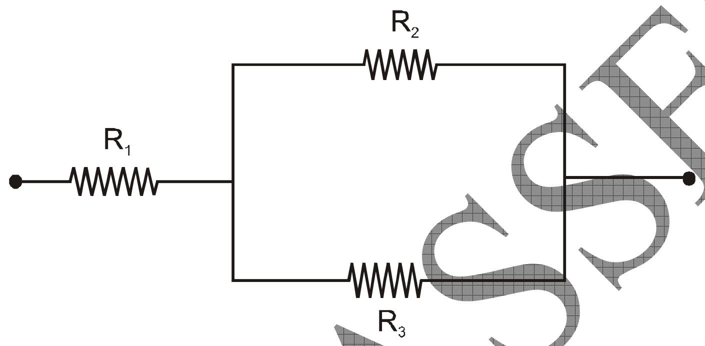
= 77.46 metres

 Head to be developed by the pump,

h = 77.46 + 6 = 83.46 metres

H.P. required = $\frac{WQh}{75\eta} = \frac{1000 \times 0.05 \times 86.46}{75 \times 0.75} = 74.2\text{HP}$

21.(C) Solid I, II and III can be thought of as three resistors, R_1, R_2 and R_3 :



Where the analogy of electric current is q and the analogy of electric potential is temperature. When the thermal conductivity of solid II is increased, its effect is the same as increasing the electric resistance of R_2. Because the heat flow, which is analogous to current flow, is constant, the temperature at face C increases.

22. 60

 < 1, hence it is underdamped vibration case Frequency of the system,

$$\omega_d = \sqrt{1-\xi^2}.\omega_n$$

$$= \omega_d = \sqrt{1-0.64} \times 100 = 60$$

23. 7

Stress concentration factor

$$= \left(1+3\frac{A}{B}\right) = (1+3\times 2) = 7$$

24.(A) At the end of heating process, when the rod is at 813 K, rate of heat absorption

$$Q_e = \frac{A_2\sigma\left(T_1^4 - T_2^4\right)}{\frac{1}{\varepsilon_1} + \frac{A_1}{A_2}\left[\frac{1}{\varepsilon_2} - 1\right]}$$

$$= \frac{\pi\times 0.022\times 1\times 5.67\times 10^{-8}\left(813^4 - 1373^4\right)}{\frac{1}{0.62} + \frac{\pi\times 0.022\times L}{\pi\times 0.018\times L}\left[\frac{1}{0.82} - 1\right]}$$

= 0150 7447 W/m

25.(B) In terms of capacity ratio and number of transfer units.

$$\epsilon = \frac{1 - \exp\left(-NTU(1+c)\right)}{1+C}$$

$$0.56 = \frac{1 - \exp\left(-15NTU\right)}{1.5}$$

or Number of transfer units, NTU = 1.221

26.(A) A system consisting of solid, liquid and vapour phase of a pure substance will have no degree of freedom. The reason is that three phases can co - exist only at one particular temperature under a particular pressure. The mere statement that these phases coexist defines the system completely. The system is therefore, said to be non - variant.

27.(D) In the absence of atmospheric drag, the work interaction due to freely falling body will be zero. However, atmospheric drag will result in increase in internal energy and the work interaction will be

$5 \times 10 = 50$ N.m.

28.(C) Given

$P_1 = 50$kPa

$V_1 = 0.2\ m^3$

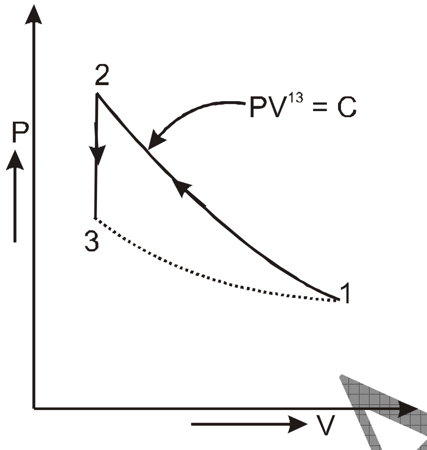
$T_1 = 90°C$

$P_2 = 2000$ kPa

$V_2 = 0.02\ m^3$

$P_1V_1 = mRT_1$

Where , $T_1 = 90 + 273 = 363$ K



$$m = \frac{P_1V_1}{RT_1} = \frac{50 \times 0.2}{0.287 \times 363} = 0.096\text{kg}$$

From $\quad P_1V_1^n = P_2V_2^n$

$$\left(\frac{V_1}{V_2}\right)^n = \frac{P_2}{P_1}$$

Taking log, $n \log_e \frac{V_1}{V_2} = \log_e \frac{P_2}{P_1}$

or $$n = \frac{\log_e\left(\frac{P_2}{P_1}\right)}{\log_e\left(\frac{V_1}{V_2}\right)} = \frac{\log_e\left(\frac{2000}{50}\right)}{\log_e\left(\frac{0.2}{0.02}\right)}$$

$= 1.6$

29.(B) The purpose of guide vanes or wicket gates is to direct water to enter into the runner vanes at a suitable angle to avoid any wastage of energy due to shock and to convert partly the pressure energy of the entering water into kinetic energy . If also regulates the supply of water according to the load on the turbine.

30.(B) For the air at 30°C DBT and 60% RH

$$P_s = \phi p_{vs}$$

$$= 0.6 \times 0.04242 = 0.2545 \text{ bar}$$

$$w_1 = \frac{0.622 P_s}{P_b - P_s} = \frac{0.622 \times 0.02525}{1.013 - 0.02525}$$

$$= 0.016 \text{ kg/ kg or dry air}$$

$$H_1 = 1.02\,T + W_1\,(2500 + 1.86T)$$

$$= 1.02 \times 30 + 0.016\,(2500 + 1.86 \times 30)$$

$$= 71.5 \text{ kJ/kg or dry air}$$

For the air at 20° C DBT,

The saturation vapour pressure at 20°C is 0.02337 bar which is less than the vapour pressure at 30°C. so the condensation takes place and air will be saturated at 20°C.

$\therefore$ $w_2 = 0.01469$ kg / kg of dry air

$$= H_1 = 1.02 \times 20 + 0.01469\,(2500 + 1.86 \times 20)$$

$$= 57.67 \text{ kJ/ kg of dry air}$$

$$w_1 - w_2 = 0.00131 \text{ kg/ kg of dry air}$$

Heat removed per kg of dry air

$$= H_1 - H_2 = 71.5 - 57.67$$

$$= 13.83 \text{ kJ/ kg of dry air}$$

Weight of dry passing per minute

$$\frac{P_a V}{RT} = \frac{(1.013 - 0.02545) \times 10^5 \times 100}{287 \times 303}$$

$$= 113.56 \text{ kg/ min}$$

Capacity of cooling coil in ton of refrigeration

$$= \frac{w_a (h_1 - h_2)}{210} = \frac{113.56 \times 13.83}{210} = 7.48 \text{ ton}$$

31.(C) Invar is a nickel (36%) iron (64%) alloy. Standard brass contains 70 % copper and 30 % zinc.

Phosphorous bronze contains 90% copper, 9.7% tin and 0.3 % phosphorus. Muntz metal contains 60% copper, 40% zinc.

32. **0.66**

$$\eta = \frac{T_1 - T_2}{T_2} = \frac{1500 - 500}{1500} = 0.66$$

33.(A) $\left(\frac{A}{V}\right)_c = \frac{5 \times 15 \times 15}{(15)^3} = \frac{5}{15} = \frac{1}{3}$

In case cylindrical riser

$$\left(\frac{A}{V}\right)_r = \frac{6}{d}$$

$$\left(\frac{A}{V}\right)_r < \left(\frac{A}{V}\right)_c$$

$$\frac{6}{d} < \frac{1}{3}$$

d > 18.

34.(B) MI about longitudinal axis = $\frac{mr^2}{2}$

M.I. about transverse axis = $\frac{m}{12}\left(3r^2 + \ell^2\right)$

□ $\frac{mr^2}{2} = \frac{m}{12}\left(3r^2 + \ell^2\right)$,

or $\frac{\ell}{r} = \sqrt{3}$

35.(B) R = 2400 , K = 100 × 52 = 5200,

C_c = 5 × 0.1 = 0.50, C_0 = 850

$$\text{EOQ} = \sqrt{\frac{2RC_0}{C_c}\left(\frac{K}{K-R}\right)}$$

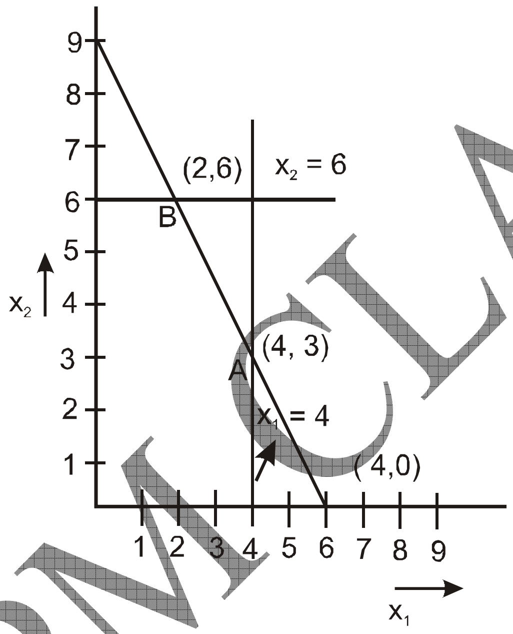
$$= \sqrt{\frac{2\times 2400\times 850}{0.5}\left(\frac{5200}{5200-2400}\right)}$$

$$= 3893$$

$\therefore$ Production run = $\frac{EOQ}{K} = \frac{3893}{5200}$

= 0.75 years = 9 months

36.(D) By Graphical method



max, $z = 3x_1 + 2x_2$

At point B , z = 18

At point A , z = 18

This means LPP has multiple optimal solutions because both points have same value.

37.(A) (a) 3, (c) 1, (d) 5, (e) 2

38.(D) The radiation incident upon the body is characterized by the temperature of the oven walls, and the absorptivity of the body for this radiation is 0.5.

 Rate of energy absorption,

G $= \alpha\sigma T^4$

$= 0.5 \times 0.1714 \times 10^{-8} \times \dfrac{\text{Btu}}{\text{hr} - \text{ft}^2 - \text{R}^4} (2000 + 460)^4 \text{R}^4$

$= 3.16 \times 10^5 \dfrac{\text{Btu}}{\text{hr} - \text{ft}^2}$

39.(B) For steady-state condition, since the external temperatures are maintained constant, the heat flow through material 1 is the same as that through material 2.

From Fourier's Conduction Law,

$$k_1 \frac{T_1 - T_2}{x_1} = k_2 \frac{T_2 - T_3}{x_3}$$

or $$\frac{k_1}{k_2} = \left(\frac{x_1}{x_2}\right)\left(\frac{T_2 - T_3}{T_1 - T_2}\right)$$

Since $$\frac{x_1}{x_2} = 1 \text{ and } \frac{T_2 - T_3}{T_1 - T_2} < 1$$

 $$\frac{k_1}{k_2} < 1$$

or $k_1 < k_2$

40.(B) The work input to the wire increases the internal energy of the wire thereby heating it.

Using c = 500 J/kg °C, for energy balance

F × d = mc ΔT

 40 × 0.8 = 0.2 × 500 ΔT

 . ΔT = 0.32°C

41.(D) Velocity of light, c = 3 × 10^8 m/s

Plank's constant = 7 × 10^{-34} Joule-sec.

c = f λ

i.e., (frequency) × (wavelength)

Energy per photon, $E = hf = \frac{hc}{\lambda}$ Joule / photon

Photons / s . m^2 $= \frac{840 \text{ W} / m^2}{7\times10^{-34} 0.3\times10^{4} / 560\times10^{-9}}$

= **2.2×10^{20}.**

42.(B) . □ $= 0.1$ Ns/m^2 (= 1 poise)

. □ $= 0.1 \times \frac{0.5}{0.001}$

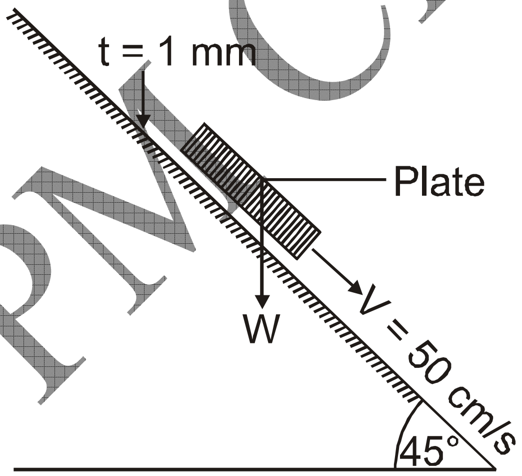
$= 50$ N/m^2

□ F = □ × area

= 50 × 1 = 50 N

Weight of plate, $W = \frac{F}{\cos 45°}$ = **70.7 N**

43.(C)



. □ = □ · $\frac{dV}{dy}$

or 1 = □ · $\frac{0.25}{0.001}$

or . □ = $\frac{0.001}{0.25}$ = **0.004 Ns/m^2**

44.(A) . □ = $\frac{F}{A} = \mu \cdot \left(\frac{dV}{dx}\right)$;

or $\frac{F}{\mu} = A\left(\frac{dV}{dx}\right)$ = constant (given)

□ $\frac{\Delta F}{F_{0°C}} = \frac{\Delta \mu}{\mu_{0°C}} = \frac{0.0182 - 0.00206}{0.01820}$

= 0.887 = **88.7%**

45.(B) $U_{max} = -\frac{1}{4\mu} \cdot \frac{dp}{dl} \cdot r_0^2$

$V = -\frac{1}{8\mu} \cdot \frac{dp}{dl} \cdot r_0^2 = -\frac{1}{2} \cdot \frac{1}{4\mu} \cdot \frac{dp}{dl} \cdot r_0^2$

= **0.5 U_{max}**

46.(B) The equation pV□ = C is applicable to reversible adiabatic process only.

For reversible adiabatic process only the following conditions must be satisfied :

(i) No heat be supplied or rejected during the process.

(ii) Expansion (or compression) be frictionless.

47.(B) Maximum shear stress $= \sqrt{\left(\frac{p}{2}\right)^2 + q^2}$

$$= \sqrt{\left(\frac{80}{2}\right)^2 + (30)^2}$$

$= 50\ N/mm^2$

Maximum tension $= 280 / mm^2$

∴ Maximum shear stress due to test

$$= \frac{280}{2} = 140\ N/m^2$$

∴ Factor of safety $= \frac{140}{50} = 2.8$

48.(B) Given: T = 45 kNm

$\tau_{max} = 90 MN/m^2$

$\theta = 0.5 \times \frac{\pi}{180} = 0.008727$ rad.

Diameter of shaft on the basis of twist

We know, $\frac{T}{I_p} = \frac{G\theta}{\ell}$

∴ $\frac{\pi}{32} D^4 = 6.445 \times 10^{-5}\ m^4$

or D = 160mm

49.(A) Diameter on the basis of shear stress

$$\frac{T}{I_p} = \frac{\tau}{R}$$

∴ $T = I_p \times \frac{\tau}{R}$

$$= \frac{\pi}{32} D^4 \times \frac{\tau}{D/2} = \frac{\pi}{16} D^3 . \tau$$

$$\therefore \quad D = \left(\frac{16T}{\pi\tau}\right)^{1/3} = \left[\frac{16 \times 45 \times 10^3}{\pi \times 90 \times 10^6}\right]^{1/3}$$

=136.5 mm

Since the diameter is chosen of the higher, hence diameter of the shaft is 160mm

$\therefore$ (Shear strain)$_{max}$ = $\frac{R\theta}{\ell}$

$= \frac{0.16}{2} \times 0.008727$

$= 6.99 \times 10^{-4}$

50.(B) Force due to gas pressure,

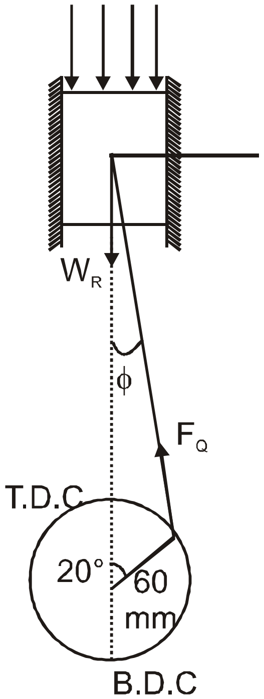
$F_g = p \times \frac{\pi}{4} D^2$

$= 700 \times \frac{\pi}{4} \times (0.1)^2$

= 5.5 kN

$n = \frac{\ell}{r} = \frac{250}{60} = 4.17$

$F_1 = m\omega^2 r\left(\cos 20^o + \frac{\cos 2\theta}{n}\right)$



$= 1.1 \times (209.5)^2\ 0.06 \times \left(\cos 20^o + \frac{\cos 40^o}{4.17}\right)$

= 3254 N

51.(D) Net force on the piston

$= F_g + F_1 + W_R$

$= 5.5 - 3.254 + \frac{1.1 \times 9.81}{1000}$

= 2.256 kN = 2256 N

Since , $\frac{\sin\theta}{\sin\phi} = n$

∴ $\sin \phi = \frac{\sin\theta}{n}$

$= \frac{\sin 20^o}{4.17} = 0.082$

∴Resultant force on the gudgeon pin,

$$F_Q = \frac{F_p}{\cos\phi} = \frac{2256}{\cos 4.7}$$

$= 2263.6$ N

52.(B) For case I, $n_1 = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = N$

For case II,

Equivalent stiffness = $\frac{k.k}{k+k} = \frac{k}{2}$

$$\therefore \quad n_2 = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{1}{\sqrt{2}}.\frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{N}{\sqrt{2}}$$

53.(C) Total Kinetic Energy

= K.E. due to translation + K.E. due to rotation

$$= \frac{1}{2}m\dot{x}^2 + \frac{1}{2}\left(\frac{mr^2}{2}\right)\left(\frac{x}{r}\right)^2$$

$$= \frac{3}{4}m\dot{x}^2$$

$$U = \frac{1}{2}Kx^2$$

$$\therefore \quad \frac{d}{dt}(T+0) = \frac{d}{dt}\left(\frac{3}{4}m\dot{x}^2 + \frac{1}{2}kx^2\right) = 0$$

$$\therefore \quad \frac{3}{4}m.2\dot{x}\ddot{x} + \frac{1}{2}k.2x\dot{x} = 0$$

$$\therefore \quad \frac{3}{2}m\ddot{x} + kx = 0$$

54.(D) Reynolds number, $R_e = \frac{\rho VD}{\mu}$

$$= \frac{1260 \times 6.0 \times 0.20}{1.50}$$

$= 1008$

Since this value is less than 2000, therefore flow is laminar.

In laminar flow in a conduct,

$$\tau_0 = \frac{8\mu V}{D} = \frac{8\times 1.50\times 6.0}{0.20} = 360 \text{ Pa}$$

In laminar flow,

head loss, $h_r = \frac{32\mu VL}{\gamma D^2} = \frac{32\times 1.50\times 6.0\times 12}{(1260\times 9.81)(0.2)^2} = 6.989$ m

55.(B) Discharge Q = AV

$$= \frac{\pi\times(0.2)^2}{4}\times 6.0$$

$= 0.188 \text{ m}^3/\text{s}$

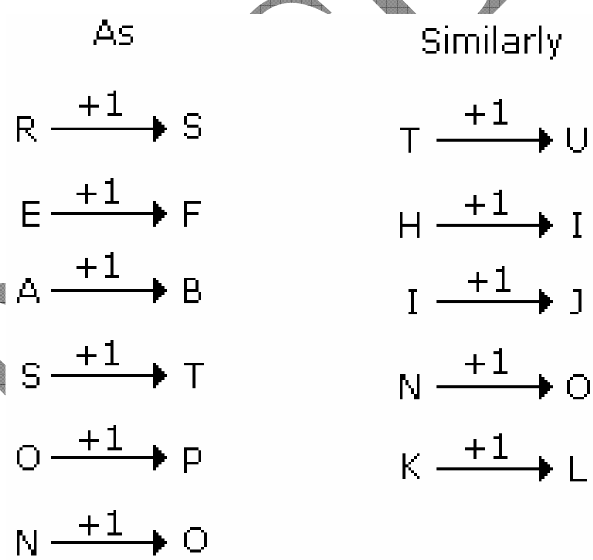
power expended,

= □Qh_rP

= (1260 × 9.81) × 0.188 × 6.989

= 16.24 kW

56.(B)



57.(B) Mortal means causing or capable of causing death while Immortal means one who is not subject to death.

58.(D) Alert means engaged in or accustomed to close observation, ie. Watchfulness.

59.(C) C.P. = Rs. $\left(\frac{100}{122.5}\times 392\right) = \text{Rs}\left(\frac{1000}{1225}\times 392\right) = 320\text{Rs}$

Profit = Rs. (392 - 320) = Rs. 72.

60.(B) Changing the symbols as given in the problem the above expression is

56÷7+13x11-15x8+2x7

Solving the BODMAS rule, we get 8+143-120+14=165-120=45

61.(B) 'Captain' is supposed to lead the battalian of 'Soldiers' int he same way as 'Leader' is supposed to lead the 'Followers' **.**

62.(B) Pork is meat from a domestic hog or pig. Similarly, mutton is meat from a mature domestic sheep.

63.(C) My uncle decided to take me and my sister to the market.

64.(B) The exports are more than imports in those years for which the exports to imports ratio are more than 1. For Company A, such years are 1995, 1996 and1997.

Thus, during these 3 years, the exports are more than the imports for Company A.

65.(B) This is a simple subtraction series. Each number is 6 less than the previous number.