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SELECTION PROCESS

BE/B. Tech or equivalent qualification in first class with an aggregate minimum of 65% marks or CGPA 6.84/10. Candidates who meet the eligibility criteria will be short-listed to appear in the Written Test, which is scheduled to be conducted at twelve venues viz., Ahmedabad, Bengaluru, Bhopal, Chandigarh, Chennai, Guwahati, Hyderabad, Kolkata, Lucknow, Mumbai, New Delhi, and Thiruvananthapuram. However, ICRB reserves its rights to prescribe a higher cut-off on need basis. ICRB also reserves its rights to cancel any written test center and re-allot the candidates to any other test center. The call letters for the written test to the short-listed candidates will be sent only by e-mail. The written test paper consists of 80 objective type questions carrying equal marks. Based on the performance in the Written Test, candidates will be short-listed for interview, the schedule and venue of which will be notified by e-mail. Written test is only a first level screening and written test score will not be considered for final selection process. Final selection will be based on the performance of the candidates in the Interview and those who secure minimum 60% marks in the interview will be eligible for consideration for empanelment, in the order of merit.

SYLLABUS

1. ENGINEERING MATHEMATICS

Linear Algebra: Matrix algebra, Systems of linear equations, Eigen values and eigenvectors.

Calculus: Functions of single variable, Limit, continuity and differentiability, Mean value theorems, Evaluation of definite and improper integrals, Partial derivatives, Total derivative, Maxima and minima, Gradient, Divergence and Curl, Vector identities, Directional derivatives, Line, Surface and Volume integrals, Stokes, Gauss and Green's theorems.

Differential equations: First order equations (linear and nonlinear), Higher order linear differential equations with constant coefficients, Cauchy's and Euler's equations, Initial and boundary value problems, Laplace transforms, Solutions of one-dimensional heat and wave equations and Laplace equation.

Complex variables: Analytic functions, Cauchy's integral theorem, Taylor and Laurent series.

Probability and Statistics: Definitions of probability and sampling theorems, Conditional probability, Mean, median, mode and standard deviation, Random variables, Poisson, Normal and Binomial distributions.

Numerical Methods: Numerical solutions of linear and non-linear algebraic equations Integration by trapezoidal and Simpson's rule, single and multi-step methods for differential equations.

EXAM PATTERN FOR SCIENTIST 'SC'

Type of Examination	:	Objective Type (Multiple Choice Questions)
No. of Questions	:	80 Questions
Apportionment of marks	:	Each Question carries three marks
Duration of Examination	:	90 minutes
Negative Marks for wrong answer	:	One mark
Maximum Marks	:	240

PREVIOUS YEARS CUT OFF FOR INTERVIEW

Note: In ISRO all candidates are considered as general category and a few seats for PWD candidates.

S. No.	Year	Cut off
1	2020	153
2	2018	185
3	2017 (Dec)	120
4	2017 (May)	139
5	2016	135
6	2015	131

SUBJECTS WISE WEIGHTAGE FOR SCIENTIST 'SC'

SI.NO.	Subject	Year of examination				
		2006	2007	2008	2009	2010
1	Strength of Materials	24	36	36	30	24
2	Engineering Mechanics	33	30	18	18	21
3	Fluid Mechanics	42	48	39	45	36
4	Heat and Mass Transfer	15	15	42	12	36
5	Thermodynamics	24	18	6	15	15
6	Power Plant Engineering	6	3	3	0	0
7	Refrigeration and Air Conditioning	3	0	0	3	0
8	Theory of Machines	30	21	15	12	9
9	Machine Design	3	6	12	21	6
10	Material science	9	12	21	21	21
11	Production Engineering	9	15	30	33	57
12	Industrial Engineering	6	3	3	3	0
13	Engineering Mathematics	36	33	15	27	15
Total Marks		240	240	240	240	240

SI.NO.	Subject	Year of examination				
		2011	2012	2013	2014	2015
1	Strength of Materials	36	24	39	51	33
2	Engineering Mechanics	21	18	12	15	12
3	Fluid Mechanics	45	48	42	63	30
4	Heat and Mass Transfer	12	12	30	24	33

A. $\frac{\varepsilon_1 \varepsilon_2}{\varepsilon_1 + \varepsilon_2 - \varepsilon_1 \varepsilon_2}$

B. $\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2}$

C. $\varepsilon_1 + \varepsilon_2$

D. $\varepsilon_1\ \varepsilon_2$

44. For a closed system, difference between the heat added to the system and work done by the gas, is equal to the change in

A. Internal energy

B. Entropy

C. Enthalpy

D. Temperature

45. The condition for reversibility of a cycle is

A. Cyclic $\int \frac{dQ}{T} < 0$

B. Cyclic $\int \frac{dQ}{T} > 0$

C. Cyclic $\int \frac{dQ}{T} = 0$

D. None of these

46. The state of a real gas if changed from pressure P_1, temperature T_1 to pressure P_2 temperature T_2 . The change in enthalpy, $h_2 - h_1$, is given by

A. $\int_{T_1}^{T_2} C_p dT$

B. $\int_{T_1}^{T_2} C_p dT + \int_{P_1}^{P_2} \left(\frac{dV}{dP}\right)_T dP$

C. $\int_{T_1}^{T_2} C_v dT + \int_{P_1}^{P_2} \left[V - T\left(\frac{dV}{dP}\right)_P\right] dP$

D. $\int_{T_1}^{T_2} C_p dT + \int_{P_1}^{P_2} \left[V - T\left(\frac{dV}{dP}\right)_P\right] dP$

47. One hundredth of a kilogram of air is compressed in a piston-cylinder device. At an instant of time when T = 400 K, the rate at which work is being done on the air is 8.165 kW, and heat is being removed at a rate of 1.0 kW, the rate of temperature rise will be

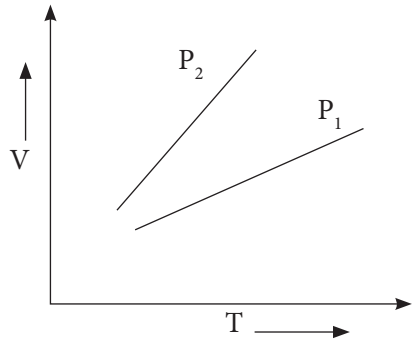
A. 10 K/s

B. 100 K/s

C. 1000 K/s

D. 10000 K/s

48. The volume V versus temperature T graphs for a certain amount of a perfect gas at two pressure P_1 and P_2 are as shown in the figure. It can be concluded that



A. The pressure P_1 is greater than the pressure P_2

B. The adiabatic index for P_1 is higher than that for P_2

C. P_1 represents monoatomic gas and P_2 represents diatomic gas

D. None of the above

49. In the polytropic process PV^n Constant, if n = 1 the process will be at

A. Constant volume

B. Constant pressure

C. Constant temperature

D. Adiabatic

50. In case of ideal triatomic gas, the ratio of specific heats C_p/C_v would be

A. 1

B. 1.33

C. 1.40

D. 1.41

51. The formation of frost on cooling coils in a refrigerator

A. Increases power consumption

B. Improves C.O.P. of the system

C. Increases heat transfer

ANSWER KEY - 2006

Question	Answer	Question	Answer	Question	Answer	Question	Answer
1	**D**	21	**C**	41	**B**	61	**B**
2	**A**	22	**D**	42	**D**	62	**C**
3	**A**	23	**A**	43	**A**	63	**C**
4	**D**	24	**C**	44	**A**	64	**D**
5	**A**	25	**C**	45	**C**	65	**C**
6	**D**	26	**D**	46	**D**	66	**C**
7	**D**	27	**A**	47	**C**	67	**B**
8	**B**	28	**B**	48	**C**	68	**A**
9	**D**	29	**D**	49	**C**	69	**A**
10	**B**	30	**C**	50	**B**	70	**B**
11	**B**	31	**B**	51	**A**	71	**C**
12	**C**	32	**D**	52	**NA**	72	**B**
13	**D**	33	**A**	53	**D**	73	**B**
14	**A**	34	**B**	54	**D**	74	**A**
15	**A**	35	**A**	55	**C**	75	**C**
16	**A**	36	**D**	56	**D**	76	**C**
17	**C**	37	**B**	57	**B**	77	**C**
18	**D**	38	**D**	58	**B**	78	**C**
19	**A**	39	**B**	59	**D**	79	**B**
20	**A**	40	**B**	60	**C**	80	**A**

» Mach number $= \sqrt{\frac{\text{inertia force}}{\text{elastic force}}}$

» Cauchy number $= \frac{\text{inertia force}}{\text{elastic force}}$

24. Answer: **option (D)**

In a velocity compounded impulse turbine, the optimum blade speed ratio $(\rho) = \frac{\cos\alpha_1}{2n}$

25. Answer: **option (C)**

» Stable equilibrium- centre of gravity(G) lies Below Metacentre(M)

» Unstable equilibrium- centre of gravity(G) lies Above Metacentre(M)

» Neutral equilibrium- centre of gravity(G) coincides with Metacentre(M)

» Floating body- buoyancy force(F_B)≥Weightof the body(W)

26. Answer: **option (A)**

Given that the diameter of pipe line reduced by 20% due to deposition of Chemicals i.e., $d_1 = d$ & $d_2 = 0.8\ d$

Darcy's equation for Head loss due to friction can be written as $h_f = \frac{fLv^2}{2gd}$

On substituting $v = \frac{Q}{A} = \frac{Q}{\frac{\pi}{4}d^2}$,

we get $h_f = \frac{fLQ^2}{3d^5}$

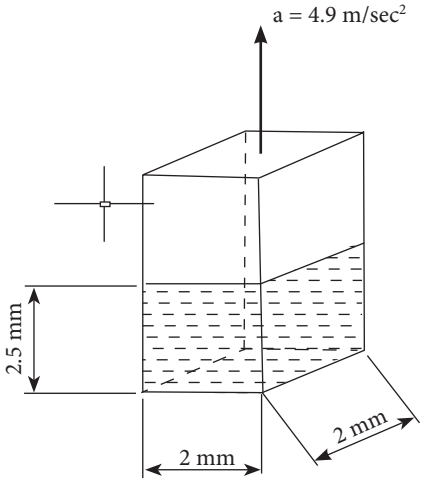
For a given head difference; $\frac{Q_1^2}{d_1^5} = \frac{Q_2^5}{d_2^5}$

$$\frac{Q_2}{Q_1} = (0.8)^{5/2}$$

$$Q_2 = 57.2\%Q_1$$

Reduction in discharge is 42.8%

27. Answer: **option (D)**



Pressure exerted by the fluid on the base of the tank = $\rho gh\left(1 + \frac{a}{g}\right)$

$= 0.8 \times 1000 \times 9.8 \times 2.5 \times \left(1 + \frac{4.9}{9.8}\right)$

$= 29.4$ kPa.

28. Answer: **option (A)**

Using hydrostatic law $P = \rho gh$

$P_A + (0.75 \times 1000 \times 9.8 \times 1.5) + (1000 \times 9.8 \times 0.60) - (13.6 \times 1000 \times 9.8 \times 0.10) = 0$

$\therefore P_A = -3.537$kPa

29. Answer: **option (B)**

Given:

$\hat{P} = 2i - 3j$, $\hat{Q} = -3i + 4j - 2k$, $\hat{R} = x\hat{i} + y\hat{j} + z\hat{k}$

For an equilibrium of forces, $\vec{P} + \vec{Q} + \vec{R} = 0$

$(2-3+x)\,\hat{i} + (-3+4+4)\,\hat{j} + (-2+2)\,\hat{k} = 0$

$x = 1, y = 1, z = 2$

$\therefore \vec{R} = \hat{i} - \hat{j} + 2\hat{k}$

30. Answer: **option (C)**

$\omega = \frac{1}{2}(\nabla \times \vec{v})$

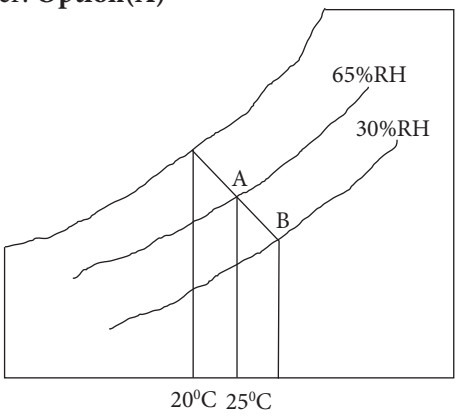
$\nabla \times \vec{v} = 2\omega$

Curl $v = 2\omega$

∴curl of a rigid body rotating with constant angular velocity ω about fixed axis with v is the velocity of a point of the body is 2ω

31. Answer: **option (C)**

28. Answer: **Option(A)**



Now the value of DBT must be greater than 25°C, so here we need to take a guess between (A) and (C), as we are going from 65%RH to 30% RH the DBT for system B should be higher i.e., 33°C.

29. Answer: **Option(C)**

Four rods with different radii r and length l are connected to two reservoirs at different temperatures then Rate of conduction heat transfer through rods is given by

$$Q = -kA\frac{dT}{dx} \text{ i.e, } Q = \propto \frac{r^2}{l}$$

Therefore, r should be maximum and L should be minimum for maximum heat transfer.

30. Answer: **Option(B)**

Equating the energies involved in the given phenomena, we have

Kinetic energy= increase in internal energy

$$\frac{1}{2}Mv^2 = mC\Delta T$$

$$0.5 \times 1000 \times (80)^2 = 20 \times 4 \times \Delta T$$

$$\Delta T = 40^0C.$$

31. Answer: **Option(B)**

Vander Waal's equation of state of a gas is $\left(p + \frac{a}{v^2}\right)(v - b) = RT$

The van der Waals equation is an equation of state that corrects for two properties of real gases that is the excluded volume of gas particles and attractive forces between gas molecules. The van der Waals equation of state approaches the ideal gas law PV= nRT as the values of these constants a, b approach zero. The constant 'a' provides correction for the intermolecular forces. Constant 'b' is a correction for finite molecular size and its value is the volume of one mole of the atoms or molecules.

32. Answer: **Option(D)**

The centrifugal tension in belts reduces power transmission.

33. Answer: **Option(A)**

» In Nodular iron or Malleable cast iron graphite is in the form of Spheroids.

» In Gray cast Iron the graphite will be in the form of flakes.

» In ductile irons, graphite is in the form of nodules rather than flakes as in grey iron. Whereas sharp graphite flakes create stress concentration points within the metal matrix, rounded nodules inhibit the creation of cracks, thus providing the enhanced ductility that gives the alloy its name.

34. Answer: **Option(C)**

Corrosion resistance of steel increases by addition of Chromium and nickel.

NOTE:

» **Nickel (NI)**-Increases strength and hardness without sacrificing ductility and toughness. It also increases resistance to corrosion and scaling at elevated temperatures when introduced in suitable quantities in high-chromium (stainless) steels.

» **Chromium (CR)**-Increases tensile strength, hardness, hardenability, toughness, resistance to wear and abrasion, resistance to corrosion, and scaling at elevated temperatures.

» Aluminium (AL)-provides greater strength, corrosion resistance, high strength to weight

67. Answer: **Option(C)**

The process layout is best suited where a few numbers of non-standardized units are to be produced.

NOTE:

» In Product Layouts (also known as assembly lines), are suitable for mass production or repetitive operations in which demand is steady and volume is high are produced efficiently by people, equipment, or departments arranged in an assembly line—that is, a series of workstations at which already-made parts are assembled.

» Arrange activities in a production line according to a sequence of operations that need to be performed to assemble a particular product.

» In a fixed-position layout, the project remains in one place, and workers and equipment come to that one work area. Examples of this type of project are a ship, a highway, a bridge, a house, and an operating table in a hospital operating room.

68. Answer: **Option(C)**

We know that pitch circle diameter is given by,

$D = m \times T$

$D = 3 \times 40$

$D = 120mm.$

The blank size from which the gear is cut is given by,

$D_B = D + 2 \times m$

$= 120 + 6$

$\therefore D_B = 126$ mm

69. Answer: **Option(B)**

Probability that both the balls will be black is given by

$$\frac{{}^{9}C_2}{{}^{22}C_2} = \frac{9!/7!2!}{22!/20!2!} = \frac{12}{77}$$

70. Answer: **Option(A)**

» In Ultrasonic machining abrasive slurry is used

» In Electro discharge machining (EDM)-Kerosene is used

» In Electro chemical machining (ECM)-salt solution is used

» In Electron Beam welding (EBW)-Vacuum is used

71. Answer: **Option(C)**

Given The rake angle of a cutting tool (α) is 15°, shear angle (ϕ)is 45° and cutting velocity (V) is 35 m/min. Then the velocity of chip along the tool face (V_c)is obtained by using sine rule, we have $\frac{V}{\sin(90 - \phi + \alpha)} = \frac{V_c}{\sin\phi}$

$$\frac{35}{\sin(90 - 45^0 + 15^0)} = \frac{V_c}{\sin 45^0}$$

$\therefore V_c = 28.5$m/min

72. Answer: **Option(A)**

$$\begin{vmatrix} 1 & 1 & 1 & 1 \\ 1 & 1+a & 1 & 1 \\ 1 & 1 & 1-b & 1 \\ 1 & 1 & 1 & 1+c \end{vmatrix}$$

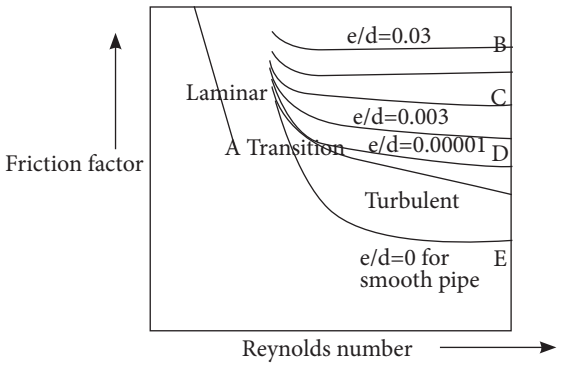
The value of the determinant is obtained by subtracting row 1 with all other rows, we get

$$\begin{vmatrix} 1 & 1 & 1 & 1 \\ 0 & a & 0 & 0 \\ 0 & 0 & -b & 0 \\ 0 & 0 & 0 & c \end{vmatrix} = -abc$$

73. Answer: **Option(D)**

$\arg\frac{z-1}{z+1} = \frac{\pi}{3}$

put, $z = x + iy$



The friction factor for Laminar flow is given by curve A whereas the curves B, C, D and E are for turbulent flow but curve E is for turbulent flow in a smooth pipe.

69. Answer: **option(C)**

Given: the lengths of the pipes,

$L_1 = 1200$ m, $L_2 = 750$m, $L_3 = 600$ m and diameters, $d_1 = 750$ mm, $d_2 = 600$ mm, $d_3 = 450$ mm

Equivalent diameter of pipe $(d_e) = 450$ mm

Equivalent system of pipes is represented as follows:

$$\frac{L_e}{d_e^5} = \frac{L_1}{d_1^5} + \frac{L_2}{d_2^5} + \frac{L_3}{d_3^5}$$

$$\frac{L_e}{(450)^5} = \frac{1200}{(750)^5} + \frac{750}{(600)^5} + \frac{600}{(450)^5}$$

The equvalent length of pipe $(L_e) = 871.3$m

70. Answer: **option(C)**

Friction drag is generally larger than the pressure drag in Flow past an air foil.

NOTE: Pressure drag is due to the shape of the object and depends on the flow separation point whereas friction drag is due to the friction between the fluid and surface of the object around which the flow occurs.

71. Answer: **option(C)**

If D is the diameter of impeller at inlet, w is the width of impeller at inlet and V_f is the velocity of flow at inlet, then discharge through a centrifugal pump is equal to $(Q) = \pi D V_f w$

72. Answer: **option(D)**

Cavitation parameter or Thomas Cavitation factor is defined by $\sigma_c = \frac{P - P_v}{\left(\frac{\rho V^2}{2}\right)}$

Where, σ_c = Cavitation number

P = reference pressure (Pa)

P_v = vapor pressure of the fluid (Pa)

ρ = density of the fluid (kg/m^3)

v = velocity of fluid (m/s)

(or)

$$\sigma_c = \frac{(H_a - H_v) - H_s}{H}$$

Where, σ_c = Cavitation number

H_a = Atmospheric pressure head

H_v = Vapour pressure of fluid corresponds to its temperature

H_s = suction head

H = working head of turbine or pump

73. Answer: **option(D)**

The maximum thickness of boundary layer in a pipe of radius R is R only.

74. Answer: **option(A)**

Applying Bernoulli's equation,

$$E_A = \frac{P}{\rho g} + Z + \frac{v^2}{2g}$$

Given, $v_1 = 1$m/sec

$$E_A = \frac{20 \times 10^3}{1000 \times 10} + 0 + \frac{(1)^2}{20} = 9.8 \text{ m}$$

$A_1 V_1 = A_2 V_2$

$$V_2 = \frac{A_1 V_1}{A_2} = \frac{\frac{\pi}{4}(1)^2}{\frac{\pi}{4}(0.5)^2} = 4$$

$$E_B = \frac{20 \times 10^3}{1000 \times 10} + 2 + \frac{(4)^2}{20} = 4.8 \text{ m}$$

F(s+a)

- If $\{f(t)\}=F(s)$, then the value of $L\{e^{at}f(t)\}$ is $F(s-a)$

50. Answer: option A

If the probability of an event happening is $\frac{1}{3}$

Then the probability of an event not happening is $= 1 - \frac{1}{3} = \frac{2}{3}$

Then the value of odds against the event happening is $\frac{2}{3}:\frac{1}{3} = 2:1$

So, the odds against happening of A are 2:1.

51. Answer: option C

Rapping or shaking Allowance:

At the time of pattern removal, the pattern is rapped all around the vertical faces to enlarge the mould cavity slightly to facilitates its removal, hence the casting is slightly increased in size. In order to compensate for this increase, the pattern should be initially made slightly smaller. It is a negative allowance and is to be applied only to those dimensions, which are parallel to the parting plane. For small and medium sized castings, this allowance can be ignored. Large sized and precision castings, however, shaking allowance is to be considered.

Shrinkage or contraction allowance:

Liquid shrinkage refers to the reduction in volume when the metal changes temperature from pouring to solidus temperature in liquid state. To account for this, risers are provided in the moulds.

Solidification shrinkage refers to the reduction in volume when metal changes from liquid to solid state at the solidus temperature. To account for this, risers are provided in the moulds.

Solid shrinkage is the reduction in volume caused when a metal loses temperature in the solid state. The shrinkage allowance is provided to take care of this reduction.

Draft or taper allowance:

To reduce the chances of the damage of the mould cavity at the time of pattern removal, the vertical faces of the pattern are always tapered from the parting line. This provision is called draft allowance.

Machining or finish allowance:

It is given due to the following reasons:

i. For removing surface roughness, scale, slag, dirt and other imperfections from the casting.

ii. For obtaining exact dimensions on the casting.

iii. To achieve desired surface finish on the casting.

Distortion or Camber Allowance:

Sometimes castings, because of their size, shape and type of metal, tend to warp or distort during shrinkage period depending on the cooling speed. This is particularly so for weaker sections such as long flat portions, V, U sections or in a complicated casting which may have thin and long sections which are connected to thick sections.

52. Answer: option A

Welding Spatter is welding defect. Weld Spatter is defined as small particles of molten metal expelled from the weld puddle that adhere to the base metal surface. The primary cause for the formation of weld spatter is a disturbance in the molten weld puddle during the transfer of wire into the weld.

53. Answer: option A

Annealing is a heat treatment process which alters the microstructure of a material to change its mechanical or electrical properties. Typically, in steels, annealing is used to reduce hardness, to improve machining characteristics, to relieve stress, to soften the metal, to permit further cold working, increase ductility and help eliminate internal stresses.

54. Answer: option C

refers to the sequence of operation to be performed.

69. Answer: option D

Given: shaft of size $30^{+0.04}_{-0.02}$ mm

Upper limit of shaft =30.04 mm

Lower limit of shaft =29.98 mm

bush of size $30^{+0.06}_{-0.03}$ mm

Upper limit of bush =30.06 mm

Lower limit of bush =30.03 mm

The maximum interference =upper limit of shaft – lower limit of hole

$= 30.04 - 30.03 = 0.01$ mm

70. Answer: option B

A ratchet screw in micrometer is provided to maintain constant pressure on the job.

71. Answer: option D

The torque that can be transmitted safely by the spur gear tooth at zero pitch line velocity is known as Stalling torque.

72. Answer: option A

Given: m = 10 kg, t = 10 mm, r = 100 mm = 0.01m, N = 600 rpm

We have,

$$I = \frac{1}{2}mr^2 = \frac{1}{2} \times 10 \times 0.01^2 = 0.05 \text{ kg} - \text{m}^2.$$

$$\omega = \frac{2\pi N}{60} = \frac{2\pi \times 600}{60} = 62.84 \text{ rad/s.}$$

The kinetic energy of flywheel is

$$KE = \frac{1}{2}I\omega^2 = \frac{1}{2} \times 0.05 \times 62.84^2 = 98.7 \text{ J.}$$

73. Answer: option B

In a gear with pitch circle diameter 'd' and total number of teeth 'T', the circular pitch of gear is defined as

$$P_C = \frac{\pi d}{T}$$

Note: module (m) $= \frac{d}{T}$

Diametral pitch $(P_d) = \frac{T}{d}$

74. Answer: option A

Given: Maximum load (P_{max}) = 990 kN, No. of bolts (N) = 40

The design stress for bolt material is 330 N/mm^2.

We have,

The design stress for bolt material

$$= \frac{P_{max}}{N \times \text{Are of cross section of bolt}}$$

$$330 = \frac{990 \times 10^3}{40 \times \frac{\pi}{4}d^2}$$

$$d^2 = 95.5 \text{ mm}$$

$$\therefore d = 9.77 \approx 9.8 \text{ mm.}$$

75. Answer: option C

A key connecting a flange coupling to shaft is likely to fail in Shear.