DRDO and ISRO

Previous Solved Papers

(Technical & Non-Technical)

ME

MECHANICAL ENGINEERING

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State Engineering Services Examinations & Public Sector Examinations

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DRDO & ISRO: Previous Years Solved Papers
Mechanical Engineering & Refrigeration and Air-Conditioning

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Preface

When in fifteenth century, some audacious mariners had sailed to discover America; in the eyes of their contemporaries it wasn't justifiable but the fervour to uncover America from rest of the world made them to set the voyage. As it is rightly said "Heritage of man is not the earth but the entire universe"; and now man dares to assault the sky, just because of thinking what was never thought

B. Singh (Ex. IES)

To help all aspirants looking forward to be the part of INDIA's next space exploration MADE EASY team has solved accurately and in detail all previous years' papers of DRDO and ISRO.

MADE EASY team has made deep study of previous exam papers and observed that a good percentage of questions are repetitive. This book containing fully explained questions from 2006 onwards will serve as an effective tool to succeed in examination.

I would like to acknowledge efforts of entire MADE EASY team who worked hard to solve previous years' papers with accuracy and I hope this book will stand upto the expectations of aspirants and my desire to serve student fraternity by providing best study material and quality guidance will get accomplished.

With Best Wishes

B. Singh

CMD, MADE EASY Group

DRDO and ISRO
Mechanical Engineering & RAC
Previous Years Solved Papers

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ME

DRDO

Defence Research and Development Organisation

(Technical & Non-Technical Sections)

- 2008 (Objective)
- 2009 (Objective)
- 2019 (Conventional)

Previous Solved Papers

1 DRDO 2008 : ME

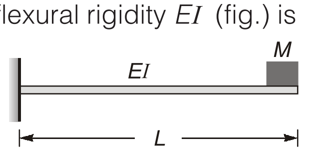
(Defence Research and Development Organisation)

SECTION-A (TECHNICAL)

Q.1 In the case of a curved beam subjected to pure bending, which of the following is true?
(a) Neutral axis coincides with the centroidal axis.
(b) Neutral axis lies between the centroidal axis and the center of curvature.
(c) Location of neutral axis depends upon the magnitude of bending moment.
(d) There is no neutral axis.

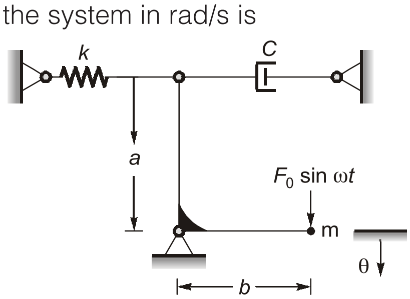
Q.2 A 10 m radius thin spherical tank is to be used to store gas. If the wall thickness of the tank is 10 mm and the allowable tensile stress for the material of the tank is 125 MPa, the maximum possible gas pressure (neglecting radial stress) is
(a) 0.25 MPa (b) 0.125 MPa
(c) 0.5 MPa (d) 1 MPa

Q.3 Natural frequency (rad/s) of mass M on the free end of a cantilever beam of negligible mass length L and flexural rigidity EI (fig.) is



(a) $\sqrt{\dfrac{EI}{3ML^3}}$ (b) $\dfrac{1}{3}\sqrt{\dfrac{EI}{ML^3}}$
(c) $\sqrt{\dfrac{3EI}{ML^3}}$ (d) $\sqrt[3]{\dfrac{EI}{ML^3}}$

Q.4 For the system shown in figure, the angular displacement θ, the undamped natural frequency of the system in rad/s is

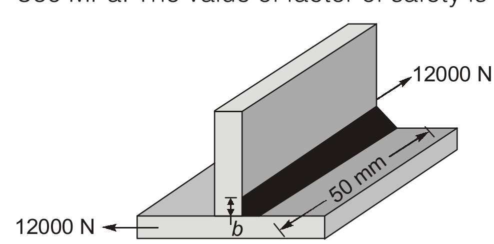


(a) $\dfrac{a}{b}\sqrt{\dfrac{k}{m}}$ (b) $\dfrac{b}{a}\sqrt{\dfrac{k}{m}}$
(c) $\sqrt{\dfrac{ak}{bm}}$ (d) $\sqrt{\dfrac{bk}{am}}$

Q.5 For a one degree of freedom system described by the differential equation $10\ddot{x} + 200\dot{x} + 810x = 0$ (units as per SI system), which of the following is true?
(a) The system is under damped
(b) The system is over damped
(c) The system is critically damped
(d) The system has no damping

Q.6 Spur gears are used for
(a) connecting two intersecting shafts
(b) transmitting power between two intersecting shafts
(c) transmitting power between two parallel shafts
(d) transmitting power between inline shafts

Q.7 A 6 mm fillet weld is 50 mm long and carries a steady load of 12000 N along the weld as shown in figure. The weld metal has yield strength of 360 MPa. The value of factor of safety is



(a) 1.59 (b) 3.18
(c) 4.18 (d) 6.36

Q.8 Which of the following bearings are termed as anti friction bearings?
(a) Journal bearings
(b) Gas lubricated bearings
(c) Ball and roller bearings
(d) Air bearings

Answers DRDO-2008

1.	(b)	2.	(a)	3.	(c)	4.	(a)	5.	(b)	6.	(c)	7.	(b)	8.	(c)
9.	(b)	10.	(c)	11.	(b)	12.	(b)	13.	(a)	14.	(d)	15.	(a)	16.	(d)
17.	(b)	18.	(a)	19.	(b)	20.	(d)	21.	(d)	22.	(a)	23.	(c)	24.	(b)
25.	(a)	26.	(c)	27.	(c)	28.	(d)	29.	(b)	30.	(b)	31.	(d)	32.	(c)
33.	(d)	34.	(b)	35.	(c)	36.	(b)	37.	(a)	38.	(b)	39.	(c)	40.	(a)
41.	(c)	42.	(a)	43.	(d)	44.	(c)	45.	(b)	46.	(a)	47.	(c)	48.	(d)
49.	(d)	50.	(d)	51.	(d)	52.	(b)	53.	(b)	54.	(c)	55.	(b)	56.	(b)
57.	(d)	58.	(a)	59.	(d)	60.	(d)	61.	(b)	62.	(c)	63.	(d)	64.	(a)
65.	(d)	66.	(c)	67.	(b)	68.	(c)	69.	(d)	70.	(d)	71.	(c)	72.	(d)
73.	(c)	74.	(d)	75.	(c)	76.	(a)	77.	(a)	78.	(a)	79.	(b)	80.	(a)
81.	(b)	82.	(a)	83.	(a)	84.	(b)	85.	(b)	86.	(b)	87.	(a)	88.	(a)
89.	(a)	90.	(a)	91.	(c)	92.	(b)	93.	(b)	94.	(d)	95.	(c)	96.	(a)
97.	(b)	98.	(a)	99.	(c)	100.	(a)	101.	(d)	102.	(a)	103.	(c)	104.	(a)
105.	(c)	106.	(d)	107.	(b)	108.	(c)	109.	(b)	110.	(a)	111.	(d)	112.	(c)
113.	(a)	114.	(d)	115.	(a)	116.	(c)	117.	(b)	118.	(d)	119.	(a)	120.	(a)
121.	(b)	122.	(c)	123.	(d)	124.	(b)	125.	(c)	126.	(d)	127.	(b)	128.	(a)
129.	(b)	130.	(b)	131.	(c)	132.	(b)	133.	(b)	134.	(c)	135.	(a)	136.	(b)
137.	(a)	138.	(d)	139.	(a)	140.	(b)	141.	(d)	142.	(b)	143.	(c)	144.	(a)
145.	(d)	146.	(c)	147.	(d)	148.	(c)	149.	(b)	150.	(c)				

Explanations DRDO-2008

2. (a)

For spherical tank
hoop stresses

$$\sigma_t = \frac{pd}{4t} \le 125$$

$$p \le 125 \times \frac{4t}{d}$$

or $$p \le 125 \times \frac{4 \times 10}{20000}$$

or $$p \le 0.25 \text{ MPa}$$

$$p_{max} = \mathbf{0.25\ MPa}$$

3. (c)

Natural frequency con.

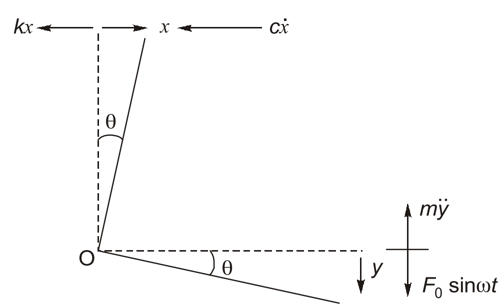
$$\omega_n = \sqrt{\frac{g}{\Delta}}$$

For a cantilever beam

$$\Delta = \frac{MgL^3}{3EI}$$

$$\omega_n = \sqrt{\frac{3EI}{(ML^3)}} \text{ rad/s}$$

4. (a)



$$\frac{x}{a} = \frac{y}{b} = \theta$$

$$x = \frac{a}{b}y$$

$$\Sigma M_o = 0 \text{ (moment about pivot point)}$$

$$\Rightarrow (m\ddot{y})b + kxa + c\dot{x}a = F_0 b \sin\omega t$$

$$\Rightarrow mb^2\ddot{\theta} + ka^2\theta + ca^2\dot{\theta} = F_0 b \sin\omega t$$

Undamped natural frequency,

$$\omega_n = \left(\frac{ka^2}{mb^2}\right)^{1/2} = \frac{a}{b}\sqrt{\frac{k}{m}}$$

5. (b)

On comparing given equation with

$$\ddot{x} + 2(\xi\omega_n)\dot{x} + \omega_n^2 x = 0$$

We will get

$$2\xi\omega_n = 20 \text{ and } \omega_n = 9$$

$$\Rightarrow \quad \xi\omega_n = 10$$

$$\xi = \frac{10}{9} = 1.1$$

$$\xi > 1$$

(Hence system is overdamped)

7. (b)

Shear stress

$$\tau = \frac{P}{0.707hl} = \frac{12000}{0.707 \times 6 \times 50}$$

$$= \mathbf{56.57\ N/mm^2}$$

$$\text{FOS} = \frac{\text{yield strength/2}}{\text{shear stress induced}}$$

$$= \frac{180 \times 10^6}{56.57 \times 10^6} = \mathbf{3.18}$$

9. (b)

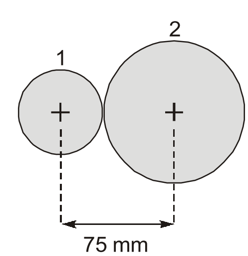
Velocity of piston

$$V_p = \omega r\left(\sin\theta + \frac{\sin 2\theta}{2n}\right)$$

In this case $\theta = 90°$, $V_p = \omega r$

$$r = \frac{V_p}{\omega} = \frac{2}{20} = 0.1 \text{ m} = \mathbf{10\ cm}$$

10. (a)



By law of gearing

$$\omega_1 r_1 = \omega_2 r_2$$

$$\omega_2 = 0.5\,\omega_2$$

$$\therefore \quad r_1 = 0.5\, r_2$$

$$r_1 + r_2 = 75$$

$$1.5\, r_2 = 75 \Rightarrow r_2 = 50 \text{ mm},\ d_2 = 100 \text{ mm}$$

$$r_1 = 25 \text{ mm},\ d_1 = 50 \text{ mm}$$

11. (b)

Shearing area = hub length (or key length)
× width of key (or side of square key)
$= l \times d$

$$\text{Torque, } T = \tau(ld) \times \frac{D}{2}$$

3 DRDO 2019 : ME

(Defence Research and Development Organisation)

Paper - I

Q.1 (a) A pressure cooker 6 litres in volume contains 5 kg of water, where the liquid is in equilibrium with the vapour above it, at 30°C. The cooker with its lid closed and weight on, is heated until the vapour produced results in an increase in pressure, and the weight just lifts up at 2 bar.

(i) Calculate the heat transferred in the process.

(ii) If the flame heating the cooker is at 400°C, calculate the entropy generation due to the external irreversibility.

Assume that the heating of water, is reversible, neglect heating of the cooker body; assume heat transfer to water takes place at its average temperature for the above process. Use property data given below.

$T(°C)$	P(kPa)	$v_f\ (m^3/kg)$	$v_{fg}\ (m^3/kg)$	u_f (kJ/kg)	u_{fg} (kJ/kg)
30	4.246	0.001004	32.8922	125.77	2290.81
120.23	200	0.001061	0.884467	504.47	2025.02

$T(°C)$	P(kPa)	$h_f\ (m^3/kg)$	h_{fg} (kJ/kg)	s_f (kJ/kgK)	s_{fg} (kJ/kgK)
30	4.246	125.77	2430.48	0.4369	8.0164
120.23	200	504.68	2201.96	1.5300	5.5970

[DRDO 2019 : 20 Marks]

Solution:

Given data: $V = 6 \times 10^{-3}\ m^3$, $m = 5$ kg,

At 30°,

$$P_1 = 4.246\ \text{kPa},\ V_f = 0.001004\ m^3/kg$$

$$v_{fg} = 32.8922\ m^3/kg,\ u_f = 125.77\ kJ/kg$$

$$u_{fg} = 2290.81\ kJ/kg$$

$$\nu_1 = \frac{6\times10^{-3}}{5} = 1.2\times10^{-3}\ m^3/kg$$

At 30°,

$$1.2 \times 10^{-3} = 0.001004 + x_1 \times 32.8922$$

$$x_1 = 5.958 \times 10^{-6}$$

$$u_1 = u_f + x_1.u_{fg} = 125.77 + 5.958 \times 10^{-6} \times 2290.81$$

$$h_1 = 125.7836\ kJ/kg = 125.77 + 5.968 \times 10^{-6} \times 2430.48$$

$$= 125.7845\ kJ/kg$$

$$s_1 = S_{f1} + x_1 S_{fg} = 0.4369\ kJ/kgK$$

At 2 bar,

$$0.0012 = 0.001061 + x_2 \times 0.884467$$

$$x_2 = 1.57 \times 10^{-4}$$

$$h_2 = 504.68 + 1.57 \times 10^{-4} \times 2201.96 = 505.026\ kJ/kg$$

$$s_2 = 1.53 + 1.57 \times 10^{-4} \times 5.5970 = 1.5308\ kJ/kgK$$

(i)

$$u_2 = 504.7879\ kJ/kg$$

$$\text{Heat transfer} = dU + dW = 1895.0215\ kJ \qquad (dW = 0)$$

(ii)

$$T = 673 \text{ K}$$

$$\left(\frac{ds}{dt}\right)_{steady} = S_1 - S_2 + S_{gen} + \frac{dQ}{T}$$

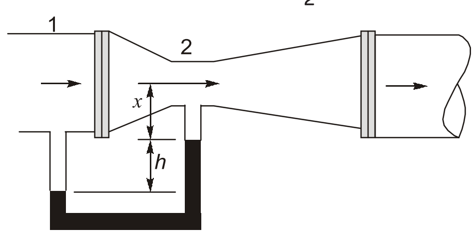
$$O = (0.4369 - 1.5308) \times 5 + S_{gen} - \frac{1895.0215}{673}$$

$$S_{gen} = 8.2853 \text{ kJ/k}$$

Q.1 (b) A venturi-meter as shown in figure below is a constriction whose pressure difference is a measure of the flow rate in the pipe. Using Bernoulli's equation for steady incompressible flow with no losses, show that the flow rate Q is related to the manometer reading h by

$$Q = \frac{A_2}{\sqrt{1-\left(\frac{D_2}{D_1}\right)^4}}\sqrt{\frac{2gh(\rho_m - 2)}{\rho}}$$

where ρ_m is the density of the manometer fluid, ρ is the density of the fluid flowing through pipe of diameter D_1, D_2 is the diameter the throat, and A_2 is the cross-sectional area at the throat.

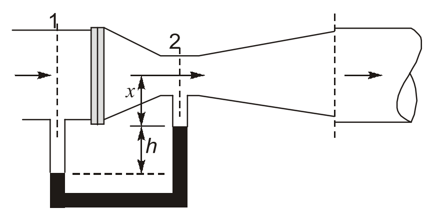


[DRDO 2019 : 20 Marks]

Solution:

Using Bernoulli's equation, for steady incompressible flow with no losses

Pipe diameter, D_1, throat diameter, D_2,



$$\text{Area of pipe, } A_1 = \frac{\pi D_1^2}{4}$$

$$\text{Area of throat, } A_2 = \frac{\pi D_2^2}{4}$$

Density of manometer fluid, ρ_m

Density of fluid, ρ.

$$\text{Discharge, } Q = A_1V_1 = A_2V_2 \quad \text{... (i)}$$

By applying bernoulli's equation in section (i) and (ii),

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2$$

For horizontal, $Z_1 = Z_2$

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + \frac{V_2^2}{2g}$$

$$V_2^2 = \left[\frac{1}{\rho g}(P_1 - P_2) + \frac{V_1^2}{2g}\right]2g$$

$$V_2 = \frac{2}{\rho}(P_1 - P_2) + V_1^2 \quad \text{... (ii)}$$

By applying,

$$P_1 + \rho g(x + h) - \rho_m gh - \rho g x = P_2$$

ME

ISRO

Indian Space Research Organization

(Technical)

• 2006 • 2007 • 2008 • 2009 • 2010
• 2011 • 2012 • 2013 • 2014 • 2015
• 2016 • 2017• 2018 • 2020

Previous Solved Papers

5 ISRO 2006 : ME

(Indian Space Research Organisation)

Q.1 In nodular iron, graphite is in the form of
(a) Cementite (b) Free carbon
(c) Flakes (d) Spheroids

Q.2 Hardness of steel depends on
(a) Amount of carbon it contains
(b) The shape and distribution of the carbides in iron
(c) Method of fabrication
(d) Contents of alloying elements

Q.3 Too high welding current in arc welding would result in
(a) Excessive spatter, under cutting along edges, irregular deposits, wasted electrodes
(b) Excessive piling up of weld metal, poor penetration, wasted electrodes
(c) too small bead, weak weld and wasted electrodes
(d) excessive piling up of weld metal, overlapping without penetration of edges, wasted electrodes

Q.4 Which of the following processes would produce strongest components?
(a) Hot rolling (b) Extrusion
(c) Cold rolling (d) Forging

Q.5 If a quantity Q is dependent on three other quantities q_1, q_2 and q_3 related such that $Q = K \times (q_1)^{n_1} \times (q_2)^{n_2} \times (q_3)^{n_3}$ then overall error $\frac{\delta Q}{Q} =$

(a) $n_1\left(\frac{\delta q_1}{q_1}\right) + n_2\left(\frac{\delta q_2}{q_2}\right) + n_3\left(\frac{\delta q_3}{q_3}\right)$

(b) $\frac{1}{n_1}\frac{\delta q_1}{q_1} + \frac{1}{n_2}\frac{\delta q_2}{q_2} + \frac{1}{n_3}\frac{\delta q_3}{q_3}$

(c) $\frac{\delta q_1}{q_1} + \frac{\delta q_2}{q_2} + \frac{\delta q_3}{q_3}$

(d) $\left(\frac{\delta q_1}{q_1}\right)^{n_1} + \left(\frac{\delta q_2}{q_2}\right)^{n_2} + \left(\frac{\delta q_3}{q_3}\right)^{n_3}$

Q.6 Which of the following has maximum hardness
(a) Austenite (b) Pearlite
(c) Troostite (d) Martensite

Q.7 The main advantage of line organization is its
(a) Effective command and control
(b) Defined responsibilities at all levels
(c) Rigid discipline in the organization
(d) All of the above

Q.8 The mathematical technique for finding the best use of limited resources in an optimum manner is known as
(a) Operation research
(b) Linear programming
(c) Network analysis
(d) Queuing theory

Q.9 Which of the following errors are generally distributed in accordance with the Gaussian distribution
(a) Controllable errors (b) Calibration errors
(c) Avoidable errors (d) Random errors

Q.10 $\frac{PL^3}{3EI}$ is the deflection under the load P of a cantilever beam (length L, modulus of elasticity E, moment of inertia I). The strain energy due to bending is

(a) $\frac{P^2L^3}{3EI}$ (b) $\frac{P^2L^3}{6EI}$

(c) $\frac{P^2L^3}{4EI}$ (d) $\frac{P^2L^3}{48EI}$

Q.11 A mass m attached to a light spring oscillates with a period of 2 sec. If the mass is increased by 2 kg, the period increases by 1 sec. The value of m is
(a) 1 kg (b) 1.6 kg
(c) 2 kg (d) 2.4 kg

Answers ISRO-2006

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

Explanations ISRO-2006

5. (a)

$$Q = K \times (q_1)^{n_1} \times (q_2)^{n_2} \times (q_3)^{n_3}$$

$$\ln Q = \ln K + n_1 \ln q_1 + n_2 \ln q_2 + n_3 \ln q_3$$

$$\frac{dQ}{Q} = n_1\left(\frac{dq_1}{q_1}\right) + n_2\left(\frac{dq_2}{q_2}\right) + n_3\left(\frac{dq_3}{q_3}\right)$$

7. (d)

Merits of line organization:

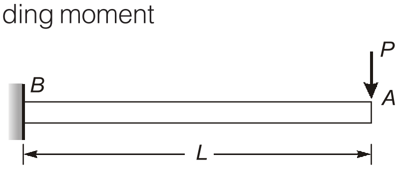
- Simplicity
- Clear-cut division of authority and responsibility
- Strong discipline
- Unified control
- Prompt decisions
- Flexibility

10. (b)

for an end loaded cantilever,

$$M = -Px$$

Bending moment



$$U = \int_0^L \frac{M^2 dx}{2EI} = \int_0^L \frac{(Px)^2 dx}{2EI}$$

$$= \frac{P^2}{2EI}\int_0^L x^2 dx = \frac{P^2L^3}{6EI}$$

Alternative approach:

$$U = \frac{1}{2} \times P \times \Delta$$

$$= \frac{1}{2} \times P \times \frac{PL^3}{3EI} = \frac{P^2L^3}{6EI}$$

11. (b)

Time period,

$$T_1 = 2\pi\sqrt{\frac{m}{K}} = 2 \quad \text{...(i)}$$

When mass in increases by 2 kg

$$T_2 = 2\pi\sqrt{\frac{m+2}{K}} = 3 \quad \text{...(ii)}$$

From Eqs. (i) and (ii)

$$\frac{m}{m+2} = \frac{4}{9}$$

$$\Rightarrow \quad m = 1.6 \text{ kg}$$

12. (c)

$$\sigma_b = \sigma_a$$

$$\frac{M}{Z} = \frac{4P}{\pi(D^2 - d^2)}$$

$$\frac{64e \cdot D}{2\pi(D^4 - d^4)} = \frac{4P}{\pi(D^2 - d^2)}$$

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

13. (d)

Young's modulus is material property not the geometric property.

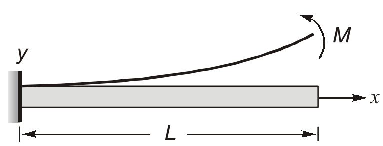
14. (a)

$$\sigma_h = \frac{Pd}{2t}$$

$$\sigma_L = \frac{Pd}{4t}$$

$$\sigma_L = \frac{1}{2}\sigma_h$$

15. (a)



for $0 < x < L$,

$$y(x) = \left(\frac{ML^2}{2EI}\right)\left(\frac{x}{L}\right)^2$$

$$y_{max} \text{ at } x = L = \frac{ML^2}{2EI}$$

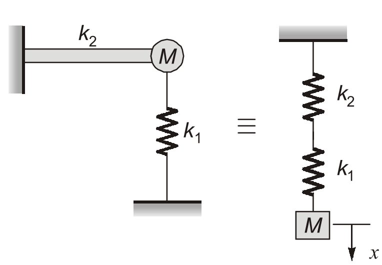
16. (a)

$$G = \frac{E}{2(1+\nu)}$$

$$\nu = 0.5 \quad \text{(given)}$$

$$G = \frac{E}{2(1.5)} = \frac{E}{3}$$

17. (c)



Two springs are in parallel, so

$$k_{eff} = k_1 + k_2$$

$$\omega = \sqrt{\frac{k_{eff}}{M}} = \sqrt{\frac{k_1 k_2}{(k_1 + k_2)M}}$$

18. (d)

Rotational Inertia,

$$I = \text{mass} \times \text{radius}^2$$

$$I_1 = m_1 r_1^2 = 36 \times 1^2 = 36 \text{ kgm}^2$$

$$I_2 = m_2 r_2^2 = 9 \times 2^2 = 36 \text{ kgm}^2$$

$$I_3 = m_3 r_3^2 = 9 \times 3^2 = 36 \text{ kgm}^2$$

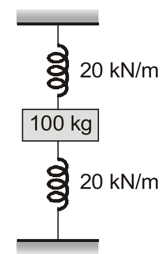
Since, $I_1 = I_2 = I_3$

∴ All same

19. (a)

∵ $F = -kx$

20. (a)



Both the springs are in parallel,

$$k_{eff} = k_1 + k_2$$

$$k_{eff} = 40 \text{ kN/m}$$

$$f_n = \frac{1}{2\pi}\sqrt{\frac{k_{eff}}{m}} = \frac{1}{2\pi}\sqrt{\frac{40 \times 10^3}{100}} = \frac{10}{\pi}$$

23. (a)

$$p = \rho g h = 9810 \times 100 \text{ N/m}^2$$

$$= \mathbf{981 \text{ kN/m}^2}$$

25. (c)

Energy, $E = \frac{1}{2}I\omega^2$

for rim type flywheel,

$$I = mR^2$$

Now, $E_1 = \frac{1}{2}mR_1^2\omega^2$

$$E_2 = \frac{1}{2}m\left[\frac{R_1}{2}\right]^2\omega^2 \text{ [for same speed]}$$

∴ $E_2 = \frac{1}{4 \times 2}mR_1^2\omega^2$

Hence, $E_2 = \frac{1}{4}E_1$

7

ISRO 2008 : ME

(Indian Space Research Organisation)

Q.1 The ultimate tensile strength and yield strength of most of the metals, when temperature falls from 0 to –150°C will
(a) Increase
(b) Decrease
(c) Remain same
(d) First increase and then decrease

Q.2 "Troosite" is obtained when
(a) Quenching steel during transformation
(b) A fully hardened steel is finally drawn at about 677ºC
(c) Steel is rapidly quenched in oil
(d) When alloy steels are rapidly quenched in water

Q.3 Induction hardening is the process of
(a) Hardening the core
(b) Uniform hardening
(c) Selective hardening
(d) Hardening surface for wear resistance

Q.4 Heavy water is used in atomic power plants as
(a) Fuel (b) Source of energy
(c) Lubricant (d) Moderator

Q.5 Which one is not the purpose of heat treatment of steels?
(a) Changing the composition of steel on the surface
(b) Changing the percentage of carbon and Si in the bulk
(c) Increasing or decreasing the grain size
(d) Removing undesirable residual stresses

Q.6 A cold chisel is made of
(a) Mild steel (b) Cast iron
(c) H.S.S. (d) High carbon

Q.7 A body which is permanently deformed is said to have undergone
(a) Elastic deformation
(b) Limit of elastic deformation
(c) Plastic deformation
(d) Uniform deformation

Q.8 The defect responsible for the phenomena of slip, by which most metals deform plastically, is known as
(a) Fracture (b) Twinning
(c) Dislocation (d) Strain hardening

Q.9 With a punch for which the maximum crushing stress is 4 times the maximum shearing stress of the plate, the biggest hole that can be punched in the plate would be of diameter equal to
(a) $\frac{1}{4} \times$ Thickness of plate
(b) $\frac{1}{2} \times$ Thickness of plate
(c) Plate thickness
(d) $2 \times$ plate thickness

Q.10 For traction applications, the type of motor best suited is
(a) Induction motor (b) Synchronous motor
(c) DC shunt motor (d) DC series motor

Q.11 On loading a ductile material in excess of a certain value, gradual increase in elongation occurs with time. Such phenomenon is known as
(a) Creep
(b) Fatigue
(c) Stress concentration
(d) None of the above

Q.12 The failure occurs at a point in a member, when the maximum shear stress in a bi-axial stress system reaches the shear stress at elastic limit in simple tension test, this is according to
(a) Rankine's theory (b) Guest' theory
(c) Lame's theory (d) None of the above

Q.13 The function of a washer is
(a) To fill the axial gap
(b) To provide cushioning effect
(c) To absorb shocks and vibrations
(d) To provide bearing area

Answers ISRO-2008

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

Explanations ISRO-2008

9. (c)

Crushing stress = 4 × shearing stress

$$\sigma = 4\tau$$

$$\frac{F}{\frac{\pi}{4}D^2} = 4\frac{F}{\pi Dt}$$

$$\Rightarrow \quad \frac{4}{D} = \frac{4}{t}$$

or $D = t$

12. (b)

Maximum shear stress theory or (Guest tresca's theory).

16. (a)

$$y = \tan^{-1}\frac{2x}{1-x^2}$$

$$\frac{dy}{dx} = \frac{1}{1+\left(\frac{2x}{1-x^2}\right)^2}\cdot\frac{(1-x^2)2-2x(-2x)}{(1-x^2)^2}$$

$$= \frac{2}{1+x^2}$$

25. (c)

Assuming $33\frac{1}{2}\%$ incentive,

T_s = standard time

T_a = time taken to complete a job

$$E = RT_a + \frac{R}{3}(T_s - T_a)$$

R = ₹ 20 per hour

T_s = 3 hour, T_a = 2 hour,

$$\therefore \quad E = 20\times 2 + \frac{20}{3}\times(3-2)$$

= ₹ 46.67

26. (d)

Cutting speed > feed rate > depth of cut.

27. (b)

$$T_m = \frac{L(1+R)B}{1000vf} \text{ in minutes}$$

L = (700 + 25 + 25) mm = 750 mm

$$R = 1/2\begin{bmatrix}\text{Ratio of return time}\\ \text{to cutting time}\end{bmatrix}$$

R = 0.5

B = 300 mm

f = 0.3 mm/stroke

$$T_m = \frac{L(1+R)B}{1000\,vf}$$

$$= \frac{750(1+0.5)300}{1000\times 9\times 0.3}$$

= 12.5 min

21 ISRO 2020 : RAC

(Indian Space Research Organisation : 12/01/2020)

Q.1 A furnace wall made of steel plate 10 mm thick and thermal conductivity 15 kcal/m-hr-°C is lined inside with silica brick of 150 mm thick of thermal conductivity 1.75 kcal/m-hr-°C and on outside with magnesia bricks of 200 mm thick with thermal conductivity of 4.5 kcal/m-hr-°C. The total resistance of the composite wall will be

(a) 0.13 °C-hr/kcal (b) 0.23 °C-hr/kcal
(c) 0.03 °C-hr/kcal (d) 0.33 °C-hr/kcal

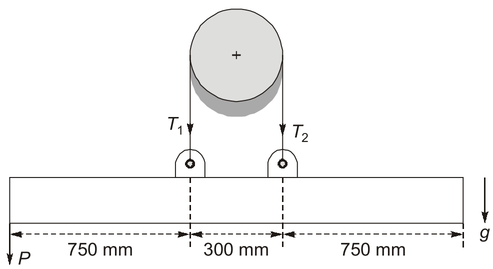
Q.2 A water turbine delivering 10 MW power is to be tested with the help of a geometrically similar 1:10 model which runs at the same speed and efficiency. The power developed by the model will be

(a) 10 W (b) 100 W
(c) 1000 W (d) 10000 W

Q.3 A hot fluid is flowing through a long pipe of 4 cm outer diameter and covered with 2 cm thick insulation. It is proposed to reduce the conduction heat loss to the surroundings to one third of the present rate by increasing the same insulation thickness. The additional thickness of insulation required will be

(a) 2 cm (b) 6 cm
(c) 9 cm (d) 12 cm

Q.4 A uniform beam of mass density 74 kg/m and length 1.8 m is suspended symmetrically as shown in figure. Calculate the maximum force *P* that can be supported without tipping the beam. Take the coefficient of static friction between the cord and the cylinder to be 7/22.



(a) 100.7 N (b) 200.9 N
(c) 150.8 N (d) 50.2 N

Q.5 For which of the following situations, zeroth law of thermodynamics will not be applicable?

(a) 50 cc of water at 25°C is mixed with 150 cc of water at 25°C
(b) 500 cc of milk at 15°C is mixed with 100 cc of water at 15°C
(c) 5 kg of wet stream at 100°C is mixed with 50 kg of dry and saturated steam at 100°C
(d) 10 cc of water at 20°C is mixed with 10 cc of sulphuric acid at 20°C.

Q.6 A system undergoes a change of state during which 100 kJ of heat is transferred to it and it does 50 kJ of work. The system is brought back to its original state through a process during which 120 kJ of heat is transferred to it. The work done by the system in kJ is

(a) 50 (b) 70
(c) 170 (d) 200

Q.7 90 kilograms of ice at 0°C is completely melted. Find the entropy change in kJ/K, if final temperature is 0°C.

(a) 0 (b) 85
(c) 45 (d) 105

Q.8 For a heat engine operating on Carnot cycle, the work output is $1/4^{th}$ of the heat transferred to the cold system. The efficiency of the Engine is

(a) 20% (b) 25%
(c) 75% (d) 50%

Q.9 Ideal Diesel cycle consists of

(a) Two adiabatic and two constant volume processes
(b) Two adiabatic and two constant pressure processes
(c) Two adiabatic, one constant pressure and one constant volume processes
(d) Two isothermal, one constant pressure and one constant volume processes

Q.72 Water with specific heat (c_p = 4 kJ/kgK) is fed to a boiler at 30°C, the enthalpy of vaporization at atmospheric pressure in the boiler is 2400 kJ/kg, the steam coming from the boiler is 0.9 dry. The net heat supplied (in kJ/kg) in the boiler is
(a) 2160 (b) 2400
(c) 2440 (d) 2280

Q.73 Subsonic and supersonic diffusers have the following geometry
(a) Divergent and convergent respectively
(b) Both divergent
(c) Both convergent
(d) Convergent and divergent respectively

Q.74 The isentropic heat drop in the nozzle of an impulse steam turbine with nozzle efficiency 0.9, blade velocity ratio 0.5 and mean blade velocity 150 m/s in kJ/kg is
(a) 50 (b) 40
(c) 60 (d) 70

Q.75 Consider a simple gas turbine (Brayton cycle) and a gas turbine with perfect regeneration. In both the cycles, the pressure ratio is 8 and the ratio of specific heats of working medium is 1.5. The ratio of minimum to maximum temperature is 0.2 (with temperature in K) in the regenerative cycle. The ratio of the thermal efficiency of the simple cycle to that of regenerative cycle is
(a) 0.63 (b) 0.73
(c) 0.83 (d) 0.93

Q.76 A simply supported beam *PQ* is loaded by a moment of 1 kN-m at the mid span of the beam of length 1 m. The reaction forces R_p and R_q at supports *P* and *Q* respectively are
(a) 1 kN downward, 1 kN upward
(b) 0.5 kN upward, 0.5 kN downward
(c) 0.5 kN downward, 1 kN upward
(d) 0.5 kN upward, 0.5 kN upward

Q.77 Two solid shafts 'A' and 'B' are made of the same material. The shaft '*A*' is 50 mm diameter and shaft '*B*' is 100 mm diameter. The ratio of strength of shaft '*B*' compared to shaft '*A*' is
(a) $\frac{1}{2}$ (b) 2
(c) 4 (d) 8

Q.78 Two simply supported beams '*A*' and '*B*' of same breadth and depth and same material carries constant central load *W* at the centre. The span of beam *B* is double that of beam *A*. The deflection of beam *B* compared to beam *A* will be
(a) one-half (b) one-eighth
(c) four times (d) eight times

Q.79 In a beam where shear force changes its sign, the bending moment will be
(a) minimum (b) zero
(c) maximum (d) same as shear force

Q.80 The rectangular beam '*A*' has length *l*, width *b* and depth *d*. Another beam '*B*' of same material has the same length and width but depth is double that of '*A*'. The elastic strength of beam *B* compared to that of *A* will be
(a) same (b) double
(c) four times (d) six times

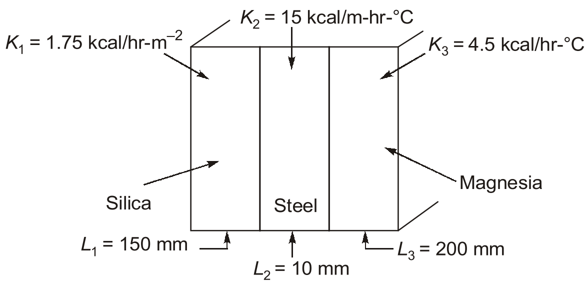
❍❍❍❍

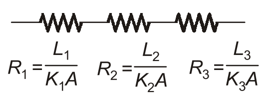
Answers ISRO-2020

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

Explanations ISRO-2018

1. (a)





Let $A = 1\text{ m}^2$

$$R_{\text{total}} = \frac{0.15}{1.75} + \frac{0.01}{15} + \frac{0.2}{4.5} = 0.13°\text{C-hr/Kcal}$$

2. (b)

Given: $P_p = 10$ MW, $P_M = ?$

$$N_m = N_p$$

$$\frac{D_M}{D_P} = \frac{1}{10}$$

For dynamic similarity of model and prototype

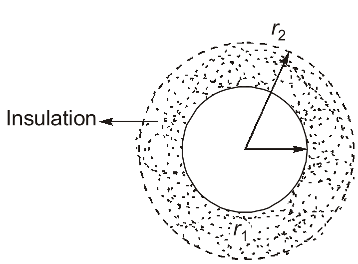
$$\left.\frac{P}{D^5N^3}\right|_P = \left.\frac{P}{D^5N^3}\right|_M$$

$$\Rightarrow \quad P_M = P_P \times \left(\frac{D_M}{D_P}\right)^5 \times \left(\frac{N_M}{N_P}\right)^3 \qquad (\because N_M = N_P)$$

$$\Rightarrow \quad P_M = 10\times10^6 \times \left(\frac{1}{10}\right)^5$$

$$\Rightarrow \quad P_M = 100 \text{ W}$$

3. (d)



For conduction heat transfer

$$Q = \frac{\Delta T}{R_{th}}$$

So, $$Q \propto \frac{1}{R_{th}}$$

Hence, $$\frac{Q_2}{Q_1} = \frac{R_1}{R_2}$$

$d_1 = 4$ cm, $r_1 = 2$ cm

$d_2 = 4 + 2 \times 2 = 8$ cm, $r_2 = 4$ cm

For cylindrical surface, $R_{th} = \dfrac{\ln(r_2/r_1)}{2\pi kl}$

$$\frac{Q_2}{Q_1} = \frac{\ln(r_2/r_1)}{2\pi kl} \times \frac{2\pi kl}{\ln(r_2'/r_1)}$$

$$\frac{1}{3} = \frac{\ln(r_2/r_1)}{\ln(r_2'/r_1)}$$

$$\Rightarrow \ln\left(\frac{r_2'}{r_1}\right) = 3\ln\left(\frac{r_2}{r_1}\right) = \ln\left(\frac{r_2}{r_1}\right)^3$$

By removing log from both side

$$\frac{r_2'}{r_1} = \left(\frac{r_2}{r_1}\right)^3 = 2^3$$

$$r_2' = 8 \times 2 = 16 \text{ cm}$$

increment $r_2' - r_2 = 16 - 4 = 12$ cm

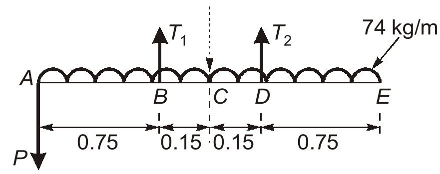
4. (a)

For rope over cylinder, Lap angle $\theta = \pi$ rad,

So, $$\frac{T_1}{T_2} = e^{\mu\theta} = e^{\frac{7}{22}\times\pi} = e^1 = 2.718$$

Load due self weight =

74 × 9.81 × 1.8 = 1306.692 N



For equilibrium forces,

$$\Sigma F = 0$$

$$\Rightarrow \quad T_1 + T_2 = P + 1306.692$$

$$\Rightarrow \quad P = 3.718T_2 - 1306.692 \qquad \text{...(i)}$$

For equilibrium of momentum, about 'A'

$$\Sigma M_A = 0$$

$$-T_1 \times 0.75 - T_2 \times 1.05 + 1306.692 \times 0.9 = 0$$

$$\Rightarrow 2.718T_2 \times 0.75 + T_2 \times 1.05 = 1176.0228$$

$$\Rightarrow \quad T_2 = \frac{1176.0228}{3.0885} = 380.7747 \text{ N}$$

$$T_1 = 2.718T_2 = 1034.945 \text{ N}$$

from (i), $P = 109.028$ N