AEROSPACE ENGINEERING

GATE – 2018

ANSWERS & EXPLANATIONS

NOTE : Use the same question paper that is uploaded on the following link for the correct sequence of questions

http://gatepathshala.com/resources.html

Quantitative Aptitude

1. (C)
2. (A)
3. (D)
4. (B)
5. (A)
6. (C)
7. (C)
8. (D)
9. None in given options is correct
10. (A)

Technical Part

1. (C)

2. 0

Sol:

$$\begin{vmatrix} 1 & 1 & -1 \\ 2 & 1 & 0 \\ 3 & 1 & 1 \end{vmatrix}$$

$$=1(1-0)-1(2-0)-1(2-3)$$

$$=1-2+1=0$$

3. (B)

Sol: In an elliptic orbit around any planet the angular moment is conserved. i.e.

$$I\omega = \text{const}$$

$$mr^2\omega = \text{const}$$

$$\omega \propto \frac{1}{r^2}$$

$\Rightarrow$ Smaller the r larger will be ω.

$\therefore$ Spacecraft will have maximum angular velocity when it is nearest i.e. at periapsis.

4. (A)

5. (C)

6. (C)

Equation of the trajectory of a space objects any plant is given by equation of the conic.

Given by,

$$\boxed{r = \frac{p}{1+e\cos(\theta - c)}}, \quad \text{where } p = \frac{h^2}{k^2} = \frac{h^2}{GM} = \frac{h^2}{\mu}$$

If $c = 0$ &

$$\boxed{r = \frac{p}{1+e\cos(\theta)} = \frac{\frac{h^2}{\mu}}{1+e\cos(\theta)}}$$

7. (C)

For jet engine maximum endurance (altitude fixed) occurs at D_{min} condition. In order to move at a speed V > Vmd & maintain steady & level flight the pilot must use the elevator to reduce the angle of attack while simultaneously increasing thrust.

8. 0.5

9. (B)

10. (B)

$$\vec{A} = x\hat{i} + y\hat{j} + zk$$

$$\nabla.\vec{A} = \frac{\partial x}{\partial x} + \frac{\partial y}{\partial y} + \frac{\partial z}{\partial z} = 1+1+1 = 3 \quad \Rightarrow \text{ Not divergence free}$$

$$\nabla \times \vec{A} = \begin{vmatrix} \hat{i} & \hat{j} & k \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial x} & \frac{\partial}{\partial x} \\ x & y & z \end{vmatrix} = \hat{i}(0) - \hat{j}(0-0) + k(0-0)$$

$$\nabla \times \vec{A} = 0 \qquad \Rightarrow \text{ Curl free}$$

11. (C)

12. 2

$$k_{eq} = k_1 + k_2$$
$$= 40 \text{ N/m}$$
$$w = \sqrt{\frac{k}{m}} = \sqrt{\frac{40}{10}} = 2 \text{ rad/sec}$$

13. (B)

14. 0.98

Inlet total pressure recovery measures the amount of the free stream flow conditions that are recovered.

The pressure recovery (Inlet) = 1PR = $\frac{Pt_2}{Pt_0}$

Inlet efficiency factor, $n_i = \frac{Pt_2}{Pt_1}$

For $M < 1$, $1PR = \frac{Pt_2}{Pt_0} = n_i \times 1 = \frac{Pt_2}{Pt_1} = \frac{98 \text{kpa}}{100 \text{ kpa}} = 0.98$

15. (B)

Coefficient of a pressure on a non-lifting circular cylinder kept in a low speed flow is given by

$$C_P = \frac{P - P_\infty}{\frac{1}{2}\rho_\infty V_\infty^2} = 1 - 4\sin^2\theta$$

Points on the surface where, $P = P_\infty$

$\Rightarrow C_P = 0$ are

$$\theta = \sin^{-1} \pm \left(\frac{1}{2}\right) = \pm 30$$

16. (B)

17. (B)

18. (C)

19. (B)

Across a moving shock wave both static and total temperature increases.

20. 1.88

Ratio of two successive amplitudes is given by logarithmic decrement

$$\delta = \ln\frac{x_1}{x_2} = \frac{2\pi\xi}{\sqrt{1-\xi^2}}$$

Given: damping ratio, $\xi = 0.1$

$$\ln\frac{x_1}{x_2} = \frac{2\pi(0.1)}{\sqrt{1-(0.1)^2}} = 0.6314 \Rightarrow \frac{x_1}{x_2} = 1.88$$

21. (B)

22. (B)

23. (C)

24. 1186.17

$$V_{max} = \sqrt{2C_P T_0} = \sqrt{2\times1005\times700} = 1186.17\text{m/s}$$

25. (A)

$$\rho = \frac{P}{RT}$$

On a hotter day, Temp increases, decreasing density. If we assume thrust is directly proportional to free- stream density then

$$(S_{L0} = S_{T0}) \propto \frac{1}{\rho_\infty^2}$$

Thus a given airplane requires a longer ground roll on hotter days.

26. 0.2

27. (C)

Given, $C_{P_i} = -1.2$

$@M_\infty = 0.6$

$$C_{P_c} = \frac{C_{P_i}}{\sqrt{1-M_\infty^2}} = \frac{-1.2}{1-0.6^2} = -1.5$$

28. 0.863

In troposphere region, $\frac{\rho_2}{\rho_1} = \left(\frac{T_2}{T_1}\right)^{\frac{g}{\lambda R}-1}$

$$\frac{\rho_2}{\rho_1} = \left(\frac{T_0 - \lambda h}{T_0}\right)^{\frac{g}{\lambda R}-1} = \left(\frac{288.16 - 0.0065 \times 3500}{288.16}\right)^{\frac{9.81}{0.0065\times287}}$$

$$\frac{\rho_{3500}}{\rho_{SL}} = 0.7045$$

$$\rho_{3500} = 0.7045 \times 1.225$$

$$\rho_{3500} = 0.863 \text{ kg/m}^3$$

29. 7800.95

$$r = R_e + h = 6400 + 150 = 6550 \text{ km}$$

$$C_1 M_e = \mu = 3.986 \times 10^{14} \text{ m}^3/\text{s}^2$$

$$V_0 = \sqrt{\frac{C_1 M_e}{R_e + h}} = \sqrt{\frac{3.986 \times 10^{14}}{6550 \times 10^3}} = 7800.95 \text{ m/s}$$

30. D

31. 18.859

$$W = 7000 \text{ N}; \; S = 16 \text{ m}^2; \; C_{Lmax} = 2.0; \; \rho = 1.23 \text{ kg/m}^3$$

$$V_{stall} = \sqrt{\frac{2W}{\rho S C_{Lmax}}} = \sqrt{\frac{2 \times 7000}{1.23 \times 16 \times 2}} = 18.859 \text{ m/s}$$

32. (B)

$$T = 500 \text{ N}, \; V = 100 \text{ m/s}, \quad \eta_p = 0.5$$

$$\eta_p = \frac{TP}{Bhp} = \frac{T \times V}{Bhp}$$

$$Bhp = \frac{TV}{\eta_p} = \frac{500 \times 100}{0.5} = 100 \text{ kw}$$

33. – 0.8

$C_{L\alpha} = 5$

$C_{M_{cg}} = 0.05 - 4\alpha \Rightarrow \dfrac{dC_m}{d\alpha} = -4$

$\tau = 1m$

$-\left(\dfrac{dC_m}{dC_L}\right) = N_0 - \dfrac{x_{cg}}{c}$

$$\Rightarrow N_0 - \frac{x_{cg}}{c} = -\frac{dC_m}{dC_L} \cdot \frac{d\alpha}{dC_L} = \frac{dC_m}{dC_L} \cdot \frac{1}{C_{L\alpha}} = +\frac{4}{5} = +0.8$$

$\therefore$ Neutral point is 0.8c distance behind the C.G

$\therefore$ -0.8 (positive is taken towards nose)

34. 12

Use energy equation and isentropic relation

$$\frac{\sigma}{y} = \frac{M}{I} \qquad \sigma = \frac{\sigma_u}{Fos} = \frac{480}{4} = 120 \text{ MPa}$$

$$M = \frac{\sigma I}{y} = \frac{120 \times 60 \times 100^3}{12 \times 50} = 12 \text{ kNm}$$

35. 0.803

36. 62.78

$M = 400000$ kg, $V_c = 240$ m/s, h = 10 km

$\dfrac{L}{D} = 15$, $g = 9.81 \text{ m/s}^2$

In S & L cruising flight $L = W = 400000 \times 9.81$

$$T = D = \frac{W}{(L/D)} = \frac{400000 \times 9.81}{15} = 261600 \text{ N}$$

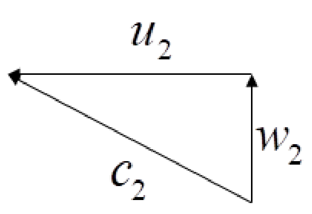
Power required to cruise, $P = D \times V$

$$P = 261600 \times 240$$

$$P = 62.784 MW$$

37. 223.606

Exit velocity triangle for straight radial blade is as follows



$$c_2 = \sqrt{u_2^2 + w_2^2} = \sqrt{200^2 + 100^2} = 223.606 \text{ m/s}$$

38. 409.81

$$\rho = 1000 \text{ kg/m}^3$$
$$g = 9.81 \text{ m/s}^2$$
$$\mathrm{P_a} = 100 \text{ kpa}$$
$$\mathrm{F_P} = \mathrm{F_{P_{air}}} + \mathrm{F_{b_{water}}} = \mathrm{P_{atm}} \times \left(1 \times 2m^2\right) + \left(\mathrm{P_{atm}} + 1000 \times 9.81 \times 0.5\right)\left(1 \times 2\right)$$
$$= 4\mathrm{P_{atm}} + 2 \times 1000 \times$$
$$= 409.81 \text{ kN}$$

39. (C)

$$M_1 = \frac{Pab^2}{L^2}$$
$$a = b = \frac{L}{2} \Rightarrow M_1 = \frac{PL}{8}$$

40. (B)

$$\mathrm{r_p} = 4 \qquad \mathrm{T_{01}} = 300\mathrm{k}$$
$$\mathrm{T_{02}} = 480 \text{ k}$$
$$\mathrm{T_{02}}^1 = \mathrm{T_{01}}\left(\mathrm{r_p}\right)^{\gamma - 1/\gamma}$$
$$= 300\left(4\right)^{1/3.5}$$
$$= 445.79 \text{ k}$$
$$\eta_c = \frac{\mathrm{T_{02}}^1 - \mathrm{T_{01}}}{\mathrm{T_{02}} - \mathrm{T_{01}}}$$
$$\eta_c = 0.81$$

41. 0.88

42. 0.707

$$d\phi = \frac{\partial \phi}{\partial x}dx + \frac{\partial \phi}{\partial y}dy$$

Along an equipotential line $\phi = c$

$$d\phi = 0 = \frac{\partial \phi}{\partial x}dx + \frac{\partial \phi}{\partial y}dy$$

$$0 = \frac{\partial}{\partial x}\left[\frac{1}{x^2+y^2+4}\right]dx + \frac{\partial}{\partial y}\left[\frac{1}{x^2+y^2+4}\right]dy$$

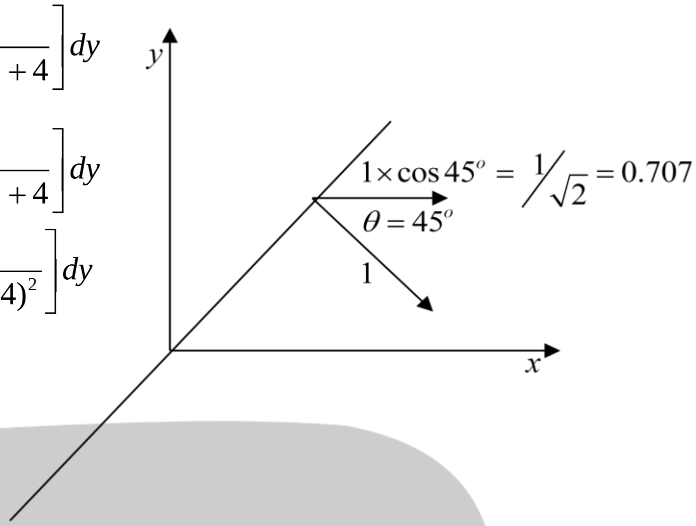
$$0 = \frac{\partial}{\partial x}\left[\frac{1}{x^2+y^2+4}\right]dx + \frac{\partial}{\partial y}\left[\frac{1}{x^2+y^2+4}\right]dy$$

$$0 = \left[\frac{-2x}{(x^2+y^2+4)^2}\right]dx + \left[\frac{2y}{(x^2+y^2+4)^2}\right]dy$$

$$0 = -2xdx + 2ydy$$

$$xdx = ydy$$

$$\frac{y^2}{2} = \frac{x^2}{2} + c$$



If it passes through (1,1) then c = 0

Therefore the equipotential line is $y = \pm x$

43. <u>3158.27</u>

$$\frac{1}{2\pi}\sqrt{\frac{3EI}{ml^3}} = f$$

$$\Rightarrow EI = 3158.27$$

44. <u>-6</u>

$$\frac{\partial \sigma_{xx}}{\partial x} + \frac{\partial \sigma_{xy}}{\partial y} = 0 \Rightarrow 2Ax + 12x = 0$$

$$\Rightarrow A = -6$$

45. (B)

$$\eta_p = \frac{2V_a}{V_e + V_a} = \frac{2(100)}{300+100} = 0.5$$

46. (C)

The Euler's equation of motion for a steady isentropic flow is given by

$$\frac{dp}{\rho} + VdV = 0$$

for isentropic flow, $\frac{p}{\rho^{\gamma}} = c \Rightarrow \rho = \frac{p^{1/\gamma}}{c^{1/\gamma}}$

$$c^{1/\gamma}\int_{p_1}^{p_2} \frac{dp}{p^{1/\gamma}} + \int_{V_1}^{V_2} VdV = 0$$

$$c^{1/\gamma}\left[\frac{p_2^{-\frac{1}{\gamma}+1}}{-\frac{1}{\gamma}+1} - \frac{p_1^{-\frac{1}{\gamma}+1}}{-\frac{1}{\gamma}+1}\right] + \frac{V_2^2}{2} - \frac{V_1^2}{2} = 0$$

$$C\left[p_2^{\frac{\gamma-1}{\gamma}} - p_1^{\frac{\gamma-1}{\gamma}}\right] = \frac{V_1^2}{2} - \frac{V_2^2}{2}$$

47. 210.303

$$V_T = \frac{V_E}{\sqrt{\frac{\rho}{\rho_{SL}}}} = \frac{130}{\sqrt{\frac{0.47}{1023}}} = 210.303 \text{ m/s}$$

48. 6.28

49. 51.93

$$Given: U_o = 20\ m/s,\ P = 1 \text{ bar},\ T = 300 \text{ K},\ \mu = 1.789\times10^{-5}\ kg/m-s,\ \delta = 1 \text{ mm}$$

$$\rho = \frac{\text{P}}{RT} = 1.1614\ \ kg/m^3$$

$$\delta = \frac{5x}{\sqrt{\text{Re}_x}} = \frac{5\sqrt{x}}{\sqrt{\frac{\rho U_o}{\mu}}}$$

$$10^{-3} = \frac{5\sqrt{x}}{\sqrt{\frac{1.1614\times20}{1.789\times10^{-5}}}}$$

$$x = 0.05193 \text{ m} = 51.93 \text{ mm}$$

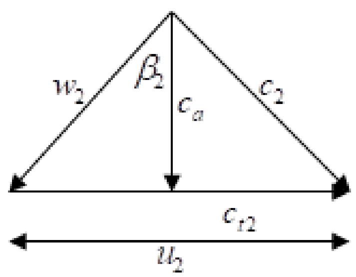
50. 215.7

$$c_a = 200\ m/s,\ \alpha_1 = 22^o$$

$\alpha_1 = \beta_2$ since 50% reaction

$$\cos\beta_2 = \frac{c_a}{w_2}$$

$$w_2 = \frac{c_a}{\cos\beta_2} = \frac{200}{\cos 22^o} = 215.7$$

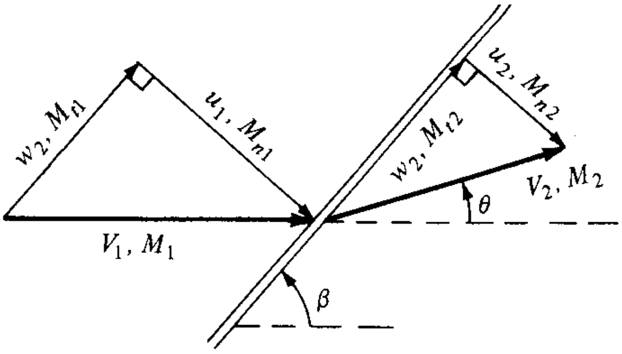


51. 2.179

$At\ M_1 = 3,\ \theta = 20^o, \beta = 36^o$

$M_{n1} = M_1 \sin\beta = 1.76334$

$$M_{n2} = \sqrt{\frac{2+(\gamma-1)M_{n1}^2}{2\gamma M_{n1}^2 - (\gamma-1)}} = 0.6249$$



From figure we have,

$$\tan(\beta-\theta) = \frac{M_{n2}}{M_{t2}}$$

$$M_{t2} = \frac{M_{n2}}{\tan(\beta-\theta)} = \frac{0.6249}{\tan(36^o - 20^o)} = 2.179$$

52. (D)

53. 18109.4

54. (C)

$$\dot{m} = -\frac{dM}{dt} = -\left(\frac{M_f - M_i}{t-0}\right) = -\left(\frac{50-150}{10}\right) = 10\ \text{kg/s}$$

$$I_{sp} = \frac{F}{\dot{m}g} = \frac{19.62\times10^3}{10\times9.81} = 200s$$

55. (B)

----END OF SOLUTION BY TEAM OF GATE PATHSHALA----

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