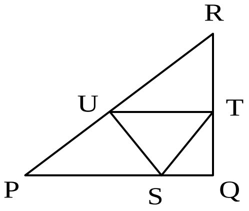
GATE 2015 – A Brief Analysis
(Based on student test Experiences in the stream of ME on 1st February, 2015 – Afternoon Session)

Section wise analysis of the paper

Section Classification	1 Mark	2 Marks	Total No of Questions
Engineering Mathematics	5	4	9
Engineering Mechanics	1	2	3
Strength of Materials	1	3	4
Design of Machine Elements	1	2	3
Theory of Machines	2	2	4
Vibrations	2	2	4
Fluid Mechanics	3	2	5
Thermal Science	2	3	5
Heat Transfer	2	2	4
Manufacturing Science	4	5	9
Industrial Engineering	2	3	5
Verbal Ability	3	2	5
Numerical Ability	2	3	5
	30	35	65

Questions from the Paper

1. For the given below figure. PS:QS = 3:1, RT:QT = 5:2, PU: UR = 1:1. If the area of QTS triangle is 20 cm^2, then the area of PQR (in cm^2) is ________.



Key: 280

Exp: Let area of triangle PQR be 'A'

$$\frac{SQ}{PQ} = \frac{1}{1+3} = \frac{1}{4}$$

$$\frac{QT}{QR} = \frac{2}{2+5} = \frac{2}{7}$$

$$\therefore \text{Area of } \Delta^{le} QTS = \frac{1}{2} \times SQ \times QT$$

$$= \frac{1}{2} \times \left(\frac{1}{4}PQ\right) \times \left(\frac{2}{7}QR\right)$$

$$= \frac{1}{4} \times \frac{2}{7} \times \left(\frac{1}{2} \times PQ \times QR\right)$$

$$= \frac{1}{14} \times \text{Area of } \Delta^{le} PQR$$

$$\text{given } 20cm^2 = \frac{1}{14} \times A$$

$$\therefore A = 14 \times 20 = 280\,cm^2$$

2. Apparent lifelessness ________ dormant life

(A) harbours (B) leads to (C) supports (D) effects

Key: (A)

Exp: Apparent: looks like

dormant: hidden

Harbour: give shelter

Effect (verb): results in

3. The boy from town was a ________ in the sleepy village

(A) dog out of herb (B) sheep from heap

(C) fish out of water (D) bird from flock

Key: (C)

Exp: From the statement, it appears that boy found it tough to adapt to a very different situation.

4. Tanya is older than Eric
Cliff is older than Tanya
Eric is older than cliff
If the first two statements are true, the third statement is
(A) True (B) False (C) Uncertain (D) Data insufficient

Key: (B)

5. Five teams have to compete a league with every team playing with every other team exactly once, before going to the next round. How many matches will they have to play to complete league round of matches?
(A) 20 (B) 10 (C) 8 (D) 15

Key: (B)

Exp:: For a match to be played, we need 2 teams
No of matches = no. of ways of selections 2 teams out of 5

$$= 5_{C_2} = 10$$

6. Consider the statements given
Statement 1: No manager is leader
Statement 2: All leaders are executives

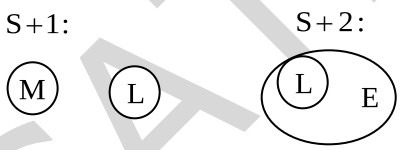
Conclusion

(I) No manager is an executive
(II) No executive is a manager

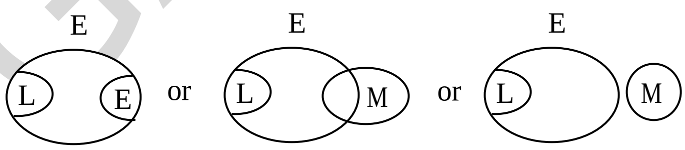
(A) Conclusion I follow
(B) Conclusion II follows
(C) Conclusion I & II follows
(D) Neither Conclusion I nor Conclusion II follows

Key: (D)

Exp:



Therefore concluding diagram can be



7. A coin is tossed thrice. Let 'x' be the event head occur in each of first two tosses. Let 'y' be event where tail occurs in third toss, and 'z' be the event tail occurs in two tosses. Based on the above information
(A) X and Y are independent (B)Y and Z are dependent
(C) Y and Z are independent (D)X and Z are independent

Key: (D)

Exp: x = {HHT, HHH}

y depends on x

z = {TTH, TTT}

∴ D is the correct choice.

8. $\lim_{x\to 0}\left(\frac{-\sin x}{2\sin x + x\cos x}\right)$ is ______.

Key: -0.333

Exp: $\lim_{x\to 0}\left(\frac{-\sin x}{2\sin x + x\cos x}\right)$ $\left(\frac{0}{0}\text{form}\right)$

$= \lim_{x\to 0}\left(\frac{-\cos x}{2\cos x + \cos x - x\sin x}\right)$ (L – Hospital Rule)

$= \frac{-1}{3}$

9. Couette flow is

(A) Steady incompressible, laminar flow in straight circular pipe.

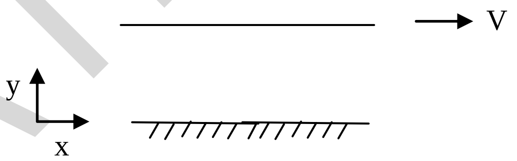
(B) Fully developed turbulent flow in straight circular pipe.

(C) Steady incompressible, laminar flow between two parallel plate.

(D) Steady incompressible, laminar flow between one fixed plate and other moving with constant velocity.

Key: (D)

Exp: Coutte flow is steady incompressible, laminar flow between one fixed plate and other moving with constant velocity.



10. A rigid container of volume $0.5\,m^3$ contains 1 kg of water at 120^oC $(V_f = 0.00106 m^3/kg,\ V_g = 0.8908 m^3/kg)$. The state of water is

(A) Compressed liquid (B) Saturated liquid

(C) A mixture of saturated liquid and saturated vapor

(D) Super heated Vapor

Key: (C)

Exp: $V = \frac{0.5}{1} m^3/kg = 0.5 m^3/kg$

Since $V_f < V < V_g$ the state of water is mix of saturated water and saturated vapor.

11. Ratio of momentum diffusivity (ν) to thermal diffusivity (α) is called

(A) Prandtl number (B)Nusselt number

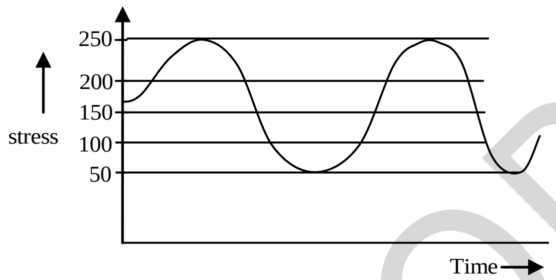
(C) Biot number (D)Lewis number.

Key: (A)

Exp: $$\Pr = \frac{\mu C_p}{k} = \frac{\rho V C_p}{k} = \frac{V}{\frac{k}{\rho c_p}} = \frac{V}{\alpha}$$

$$\text{i.e. } \Pr = \frac{\text{momentum diffusivity}(\nu)}{\text{thermal diffusivity}(\alpha)}$$

12. For given fluctuating fatigue load, the value of stress amplitude and stress ratio are respectively.



(A) 100 MPa and 5 (B) 250 MPa and 5

(C) 100 MPa and 0.20 (D) 250 MPa and 0.20

Key: (C)

Exp: $$\text{stress amplitude} = \frac{\sigma_{max} - \sigma_{min}}{2} = \frac{250-50}{2} = 100\text{ Mpa}$$

$$\text{Stress ratio} = \frac{\sigma_{min}}{\sigma_{max}} = \frac{50}{250} = 0.2$$

13. Which two of the following joining process are autogenous.

(i) Diffusion welding (ii)Electro slag welding

(iii) Tungsten inert gas welding (iv) Friction welding

(A) (i) and (iv) (B) (ii) and (iii) (C) (ii) and (iv) (D) (i) and (iii)

Key: (A)

Exp: Diffusion welding and friction welding are autogenous welding process as they do not require any filler material.

14. In notation (a/b/c): (d/e/f) for summarizing the characteristics of queuing situation, the letters ‘b’ and ‘d’ stand respectively for

(A) Service time distribution and queue discipline

(B) Number of servers and size of calling source

(C) Number of servers and queue discipline

(D) Service time distribution and maximum number of allowed in system

Key: (A)

Exp: b: Service time distribution (usually represented by ‘m’)

D: Queuing discipline (usually represented by ‘GD’)

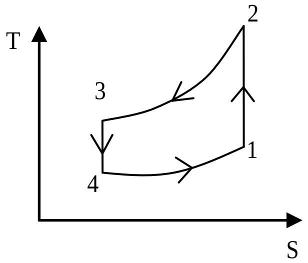
15. Strain hardening exponent, 'n' of stainless steel SS304 with distinct yield and UTS value undergoing plastic deformation is

(A) $n<0$ (B) $n = 0$ (C) $0<n<1$ (D) $n = 1$

Key: (C)

Exp: n lies between 0 and 1. 0 means material is a perfectly plastic solid, while 1 represents a 100% elastic solid.

16. The thermodynamics cycle shown in the figure (T-S diagram) indicates

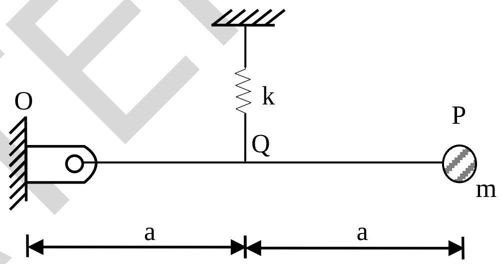


(A) Reversed carnot cycle (B) Reversed Brayton cycle
(B) Vapor compression cycle (D) Vapor absorption cycle

Key: (B)

Exp: T-S diagram represent a reversed brayton cycle used in air conditioning of aero planes where air is used as a refrigerant.

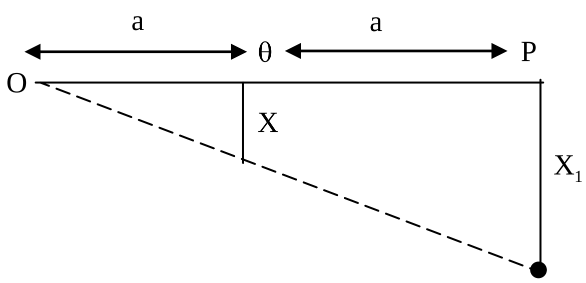
17. Figure shown a single degree of freedom. The system consists of massless rigid bar. OP hinged at 'O' and a mass 'm' at end 'P'. The natural frequency of vibration of the system



(A) $f_n = \frac{1}{2\pi}\sqrt{\frac{k}{4m}}$ (B) $f_n = \frac{1}{2\pi}\sqrt{\frac{k}{2m}}$ (C) $f_n = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$ (D) $f_n = \frac{1}{2\pi}\sqrt{\frac{2k}{m}}$

Key: (A)

Exp: force in the spring F= 2mg [from equilibrium]



Deflection as mass at P, $x_1 = \frac{x}{a} \times 2a = 2x$

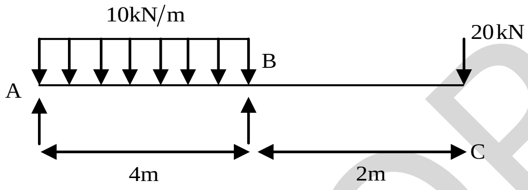
$$= 2 \times \frac{2mg}{k}$$

$$= \frac{4mg}{k}$$

$$w_n = \sqrt{\frac{g}{s}} = \sqrt{\frac{g}{x_1}} = \sqrt{\frac{k}{4m}}$$

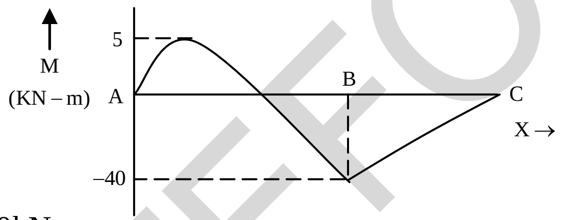
$$f_n = \frac{1}{2\pi}\omega_n = \frac{1}{2\pi}\sqrt{\frac{k}{4m}}$$

18. For overhanging beam shown in figure, the magnitude of maximum bending moment (in k.N-m) is ______________.



Key: 40

Exp: BMD:

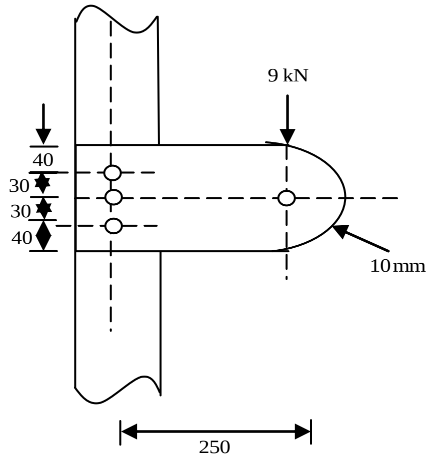


$R_A = 10kN$

$R_B = 50kN$

Maximum bending momentum occurs at reaction B an has a magnitude of 40 kN-m.

19. A cantilever bracket is bolted to column using three $M12 \times 1.75$ bolts P,Q,R. The value of Maximum shear stress developed in the bolt P(in MPa) is ______ .



All dimensions are in mm

Key: 341

Exp: P=9kN, e=250 mm

Primary shear force

$$P_p' = P_q' = P_r' = \frac{p}{3} = \frac{q}{3} = 3\text{kN}$$

Secondary shear force:

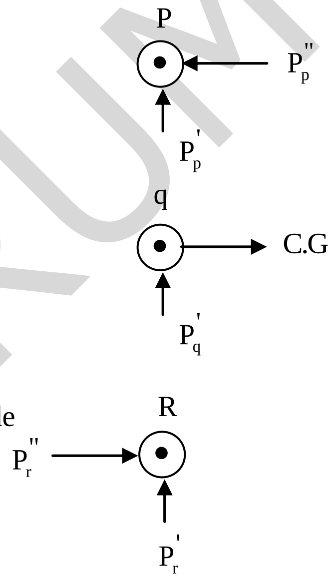
By symmetry C.G lies at the centre of bolt θ.

$\therefore r_p = 30\text{ mm}$

$r_r = 30\text{ mm}$

$r_q = 0$

$$C = \frac{Pe}{r_q^2 + r_q^2 + r_r^2} = \frac{9000 \times 250}{30^2 + 0^2 + 30^2} = 1250$$



$P_p'' = P_r'' = C$

$P_p'' = Cr_p = 37.5\text{ kN}$

$P_r' = Cr_r = 37.5\text{kN}$

$P_q'' = 0$

Resultant shear force

Due to symmetry stress in P Q R will be equal in magnitude

$$P_p = P_r = \sqrt{(3)^2 + (37.5)^2} = 38.5648\text{ kN}$$

$$\tau = \frac{P}{A} = \frac{38.5648}{\frac{\pi}{4}(0.012)^2} = 340.987\text{ MPa} \simeq 341\text{MPa}$$

20. Air in room is at 35^{o}C and 60% relative humidity (R.H). The pressure in room is 0.1 MPa. The saturated pressure at water at 35^{o}C is 5.63 kPa. The humidity ratio of the air (in gram/kg of dry air) is _____.

Key: 21.74

Exp: $\phi = \frac{P_w}{P_s} = 0.6 = \frac{P_w}{5.63}$

$\therefore P_w = 3.378\text{KPa}$

$$\text{humidity Ratio, } w = 0.622\frac{P_w}{P_a - P_w}$$

$$= 0.622 \times \frac{3.378}{100 - 3.378}$$

$$= 0.021745\text{ kg/kg of dry air}$$

or 21.745 g/kg of dry air

21. Ratio of solidification time of a cylindrical casting (height =radius) to the cubic casting of side two times the height of cylindrical casting is _____.

Key: 0.25

Exp. $t_s = k\left(\frac{V}{A}\right)^2$

For cylindrical cavity (1)

$$t_1 = k\left(\frac{\frac{\pi}{4}d^2h}{\pi dh + \frac{2\pi}{4}d^2}\right)^2 = k\left(\frac{d}{6}\right)^2 \quad (d = h)$$

for cubic casting (2)

$$t_2 = k\left(\frac{a^3}{6a^2}\right)^2 = k\left(\frac{a}{6}\right)^2 = k\left(\frac{d}{3}\right)^2 \quad (a = 2d)$$

$$\therefore \frac{t_1}{t_2} = \frac{3^2}{6^2} = 0.25$$

22. The dimensions of a cylindrical side riser (height=diameter) for a 25cm×15cm×5cm×steel casting are to be determined. For the tabulated shape factor values given below the diameter of the riser (in cm) is _______ .

Shape factor	2	4	6	8	10	12
Riser volume / casting volume	1.0	0.70	0.55	0.50	0.40	0.35

Key: 13.36

Exp: $\text{Shape factor} = \frac{l + w}{h} = \frac{25+15}{5} = 8$ then from the table

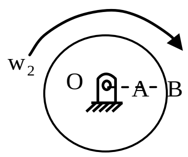
$$\therefore \frac{V_r}{V_c} = 0.5$$

$$\frac{\pi}{4}d^2h = 0.5 \times 25 \times 15 \times 5$$

$$\text{or } d^3 = 2387.324\,\text{cm}^3$$

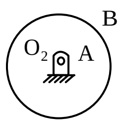
$$\therefore d = 13.365\,\text{cm}$$

23. Figure shows a wheel rotating about O. Two points A and B located along the radius of wheel have speeds of 80 m/s and 40 m/s respectively. The distance between the point A and B is 300 mm. The diameter of the wheel (in mm) is _________.



Key: 600

Exp:



$V_A = \omega\, r_A\ V_B = \omega\, r_B$

$\therefore \frac{80}{r_A} = \frac{40}{r_B}$

$\therefore 2r_B = r_A$

$r_A - r_B = 300(\text{given})$

$\therefore r_A = 300\,\text{mm}$

$\therefore$ Diameter of wheel is 600 mm

24 A prandtl tube (pitot-static tube with C = 1) is used to measure the velocity of water. The differential manometer reading is 10 mm of liquid column with a relative density of 10. Assuming g = 9.8 m/s^2 the velocity of water (in m/s) is ________.

Key: 1.32

Exp: Velocity as water $= C_v\sqrt{2gh}$

$C_v = 1$ (Given)

$h = x\left[\frac{s_g}{s_0} - 1\right] = 0.01(10-1) = 0.09\,\text{m}$

$\therefore$ velocity as flow $= \sqrt{2\times 9.8\times 0.09} = 1.328\,\text{m/s}$

25. `Newton-Raphson method is used to find the roots of equation, $x^3+2x^2+3x-1 = 0$. If the initial guess is $x_0 = 1$, then the value of x after 2^{nd} iteration is ________.

Key: 0.23

Exp:: $f = x^3+2x^2+3x-1,\ x_0 = 1$

$f' = 3x^2 + 4x + 3$

$x_1 = x_0 - \frac{f(x_0)}{f'(x_0)} = 1 - \frac{5}{10} = 0.5$

$x_2 = x_1 - \frac{f(x_1)}{f'(x_1)} = 0.5 - \frac{1.125}{4.75} = 0.5 - 0.27 = 0.23$

26. Which of the following are true, when cavitation parameter σ = 0?

(i) Local pressure is reduced to vapor pressure

(ii) Cavitation starts

(iii) Boiling of liquid starts

(iv) Cavitation stops

(A) i, ii, iv (B) ii and iii (C) i and iii (D) i, ii, iii

Key: (D)

Exp: σ = 0 implies (i), (ii) and (iii)

27. The value of $\int_c \left[\left(3x-8x^2\right)dx+\left(4y-6xy\right)dy\right]$, where C is boundary of the region bounded by x = 0, y = 0 and x+y = 1 is ________.

Key: -1

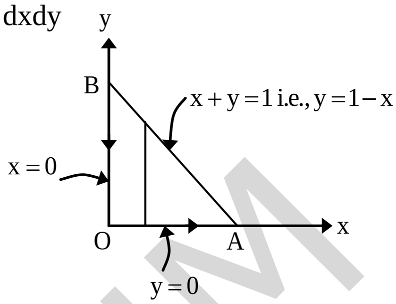
Exp: Using Green's theorem

$$\oint_C \left[\left(3x-8x^2\right)dx+\left(4y-6xy\right)dy\right]=\iint_R (-6y)-(0)\,dxdy$$

$$=\int_{x=0}^{1}\int_{y=0}^{1-x}(-6y)\,dydx$$

$$=-6\int_0^1\left(\frac{y^2}{2}\right)_0^{1-x}dx=-3\int_0^1(1-x)^2\,dx$$

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



28. In a rolling operation using rolls of diameter 500 mm if a 25 mm thick plate cannot be reduced to less than 20 mm in one pass, the coefficient of friction between the roll and the plate is __________.

Key: 0.1414

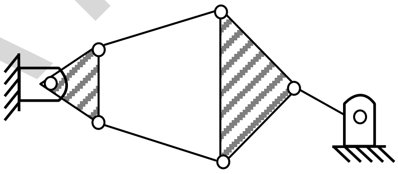
Exp: $\mu=\sqrt{\frac{(\Delta h)_{max}}{R}}$

$(\Delta h)_{max}=25-20=5\text{mm}$

$R=250\,\text{mm}$

$\therefore \mu=\sqrt{\frac{5}{250}}=0.1414$

29. The number of DOF of the linkage shown in the figure is



(A) -3 (B)0 (C) 1 (D) 2

Key: C

Exp: Number of links, N = 6

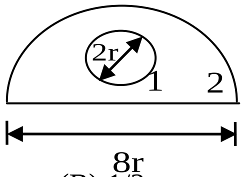
Total number as binary joints, j = 7

F = 3 (N-1) – 2j

= 15-14 = 1

Correct option is (C).

30 A solid sphere, of radius r is placed inside a hollow, closed hemispherical surface 2 of radius '4r'. The shape factor $F_{2\text{-}1}$ is



(A) 1/12 (B) 1/2 (C) 2 (D) 12

Key: (A)

Exp: (A)

$$0 < f_{11} + f_{12} = 1$$

$$\therefore f_{12} = 1$$

$$f_{21} A_2 = f_{12} A_1$$

$$\therefore f_{21} = \frac{f_{12} A_1}{A_2} = \frac{1 \times 4\pi r^2}{\frac{1}{2} 4\pi (4r)^2 + \pi (4r)^2} = \frac{1}{12}$$

31. One side of a wall at 400K and the other at 300K. The rate of heat transfer through the wall is 1000W and surrounding temperature is 25°C. Assuming no heat generation of heat within the wall, the irreversible (in W) due to heat transfer through the wall is____.

Key: 0.833

Exp: $\theta = 1000\text{w}$

$$\frac{d_{swatl}}{dt} = \dot{S}_{transfer} + \dot{S}_{gen,\,wall}$$

$$O = \sum \frac{\dot{Q}}{T} + \dot{S}_{gen,\,wall}$$

$$= \frac{1000}{400} - \frac{1000}{300} + \dot{S}_{gen,\,wall}$$

$$\therefore \dot{S}_{gen,\,wall} = 0.833\,\text{W/K}$$

32. Inverse of $P = \begin{bmatrix} 4+3i & -i \\ i & 4-3i \end{bmatrix}$, $i = \sqrt{-1}$ then P^{-1} is _________.

(A) $\frac{1}{24}\begin{bmatrix} 4+3i & i \\ -i & 4-3i \end{bmatrix}$ (B) $\frac{1}{25}\begin{bmatrix} 4-3i & i \\ -i & 4+3i \end{bmatrix}$

(C) $\frac{1}{24}\begin{bmatrix} 4-3i & -i \\ i & 4+3i \end{bmatrix}$ (D) $\frac{1}{25}\begin{bmatrix} 4-3i & -i \\ i & 4+3i \end{bmatrix}$

Key: (C)

Exp: |P| = (4+3i)(4-3i)-(i)(-i) = 16+9-1 = 24#0

$$\text{adj}\,P = \begin{bmatrix} 4-3i & -i \\ i & 4+3i \end{bmatrix}$$

$$\therefore P^{-1} = \frac{1}{24}\begin{bmatrix} 4-3i & -i \\ i & 4+3i \end{bmatrix}$$