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GATE 2019

Production & Industrial Engg.

Questions and Solutions of afternoon session

Date of Exam : 3/2/2019

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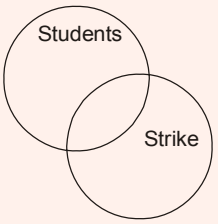
GENERAL APTITUDE

Q.1 - Q.5 Carry One Mark each.

Q.1 Some students were not involved in the strike.
If the above statement is true, which of the following conclusions is/are logically necessary?
1. Some who were involved in the strike were students.
2. No student was involved in the strike.
3. At least one student was involved in the strike.
4. Some who were not involved in the strike were students.

(a) 1 and 2 (b) 3
(c) 4 (d) 2 and 3

Ans. (c)
Given statements: Some students were not involved in the strike.
Venn diagram:



Only conclusion 4 is logically necessary.
Hence, option (c) is correct.

End of Solution

Q.2 Five numbers 10, 7, 5, 4 and 2 are to be arranged in a sequence from left to right following the directions given below:
1. No two odd or even numbers are next to each other.
2. The second number from the left is exactly half of the left-most number.
3. The middle number is exactly twice the right-most number.

Which is the second number from the right?
(a) 2 (b) 4
(c) 7 (d) 10

Ans. (c)
According to given data the only possible arrangement is
10 5 4 7 2
So, second from right will be 7.

End of Solution

Q.3 The fishermen,_____the flood victims owed their lives, were rewarded by the government.

(a) whom (b) to which
(c) to whom (d) that

Ans. (c)

End of Solution

Q.4 The radius as well as the height of a circular cone increases by 10%. The percentage increase in its volume is _____.

(a) 17.1 (b) 21.0
(c) 33.1 (d) 72.8

Ans. (c)

We know formula for volume of a (right circular) cone is $\frac{1}{3}\pi r^2 h$

Original volume (V_0)

$$V_0 = \frac{1}{3}\pi r_1^2 h_1 \quad \text{... (i)}$$

Now we know radius and height both are increased by 10%. So after increase the new volume will be

$$V_n = \frac{1}{3}\pi(1.1r_1)^2(1.1)h_1$$

$$= 1.331\left(\frac{1}{3}\pi r_1^2 h_1\right)$$

$$= 1.331\,(V_0)$$

$$\% \text{ change in volume} = \frac{V_n - V_0}{V_0} \times 100 = \frac{1.331V_0 - V_0}{V_0} \times 100$$

$$= 33.1\%$$

End of Solution

Q.5 Until Iran came along, India had never been _____ in kabaddi.

(a) defeated (b) defeating
(c) defeat (d) defeatist

Ans. (a)

Until Iran came along, India had never been defeated in Kabaddi.

If two events occur in past one after antoher, the event completing first takes past perfect tense. And another event is expressed in Simple past tense.

End of Solution

Q.6 - Q.10 Carry Two Marks each.

Q.6 Since the last one year, after a 125 basis point reduction in repo rate by the Reserve Bank of India, banking institutions have been making a demand to reduce interest rates on small saving schemes. Finally, the government announced yesterday a reduction in interest rates on small saving schemes to bring them on par with fixed deposit interest rates.

Which one of the following statements can be inferred from the given passage?

(a) Whenever the Reserve Bank of India reduces the repo rate, the interest rates on small saving schemes are also reduced

(b) Interest rates on small saving schemes are always maintained on par with fixed deposit interest rates

(c) The government sometimes takes into consideration the demands of banking institutions before reducing the interest rates on small saving schemes

(d) A reduction in interest rates on small saving schemes follow only after a reduction in repo rate by the Reserve Bank of India

Ans. **(c)**

The argument says that banking institutiions had been demanding for a reduction in interest rates for the last one year. Finally the government decided to reduce the interest rates of small saving schemes thus implying that the govt. does consider the demands of banking institutions before making any such policy decision.

End of Solution

Q.7 In a country of 1400 million population, 70% own mobile phones. Among the mobile phone owners, only 294 million access the Internet. Among these Internet users, only half buy goods from e-commerce portals. What is the percentage of these buyers in the country?

(a) 10.50 (b) 14.70

(c) 15.00 (d) 50.00

Ans. **(a)**

Total population = 1400 million

According to the question 70% of mobile phone users data is an unnecessary data. Its not necessary to calculate tabing the relevant data into consideration,

Number of internet users = 294 million

Half of which (internet) use e-commerce portal

$$\frac{294}{2} = 147$$

Percentage of thesen (e-commerce portals) in the country (out of 1400 million)

$$= \frac{147}{1400} \times 100 = 10.5\%$$

End of Solution

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Q.8 Two trains started at 7AM from the same point. The first train travelled north at a speed of 80 km/h and the second train travelled south at a speed of 100 km/h. The time at which they were 540 km apart is_____AM.

(a) 9 (b) 10

(c) 11 (d) 11.30

Ans. **(b)**

According to the concept of relative speed in opposite direction speeds should be added

$$\text{Time of activity} = \frac{\text{Sum of distance}}{\text{Sum of speeds}} = \frac{540}{100+80} = \frac{540}{180}$$

$$= 3 \text{ hours from 7 am} = 10 \text{ am}$$

End of Solution

Q.9 The nomenclature of Hindustani music has changed over the centuries. Since the medieval period *dhrupad* styles were identified as *baanis*. Terms like *gayaki* and *baaj* were used to refer to vocal and instrumental styles, respectively. With the institutionalization of music education the term *gharana* became acceptable. *Gharana* originally referred to hereditary musicians from a particular lineage, including disciples and grand disciples.

Which one of the following pairings is NOT correct?

(a) *dhrupad, baani* (b) *gayaki*, vocal

(c) *baaj*, institution (d) *gharana*, lineage

Ans. **(c)**

Baaj, institution

Following are the correct pairings:

- Dhrupad style - baani
- gayaki - vocal style
- baaj - insturmental style
- gharana - musicians from a particular lineage

End of Solution

Q.10 "I read somewhere that in ancient times the prestige of a kingdom depended upon the number of taxes that it was able to levy on its people. It was very much like the prestige of a head-hunter in his own community."

Based on the paragraph above, the prestige of a head-hunter depended upon_____

(a) the prestige of the kingdom (b) the prestige of the heads

(c) the number of taxes he could levy (d) the number of heads he could gather

Ans. **(d)**

The way prestige of a kingdom depended upon the number of taxes, the prestige of a head-hunter depended upon the number of heads he could collect.

End of Solution

PRODUCTION AND INDUSTRIAL ENGINEERING

Q.1 - Q.25 Carry One Mark each.

Q.1 For a process which is in a state of statistical control (within ± 3σ), estimated process standard deviation (σ) is 3 mm. The specification limits for the corresponding product are 100 ± 7 mm. The capability ratio C_r is_____(round off to 3 decimal places)

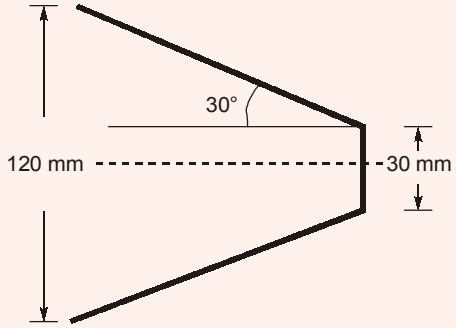
Ans. **(0.778)**

$$C_r = \frac{USL - LSL}{6\sigma} = \frac{107 - 93}{6 \times 3} = \frac{14}{18} = 0.778$$

C_r - Process capability ratio.

End of Solution

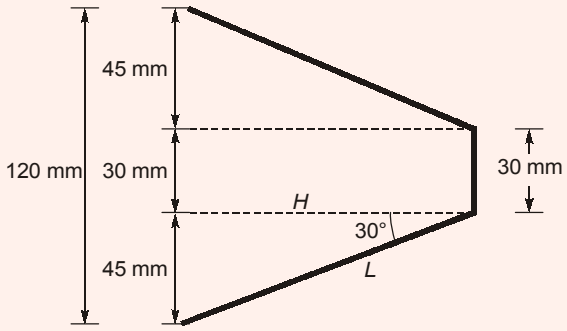
Q.2 The end product obtained using spinning process is shown in the figure. The initial blank thickness is 2.5 mm. The blank diameter (in mm) is



(a) 75 (b) 105

(c) 150 (d) 210

Ans. **(c)**



$$\frac{45}{L} = \sin 30°$$

or $$L = \frac{45}{\sin 30°} = 90 \text{ mm}$$

If 30 mm diameter is metal part (According to diagram)

$$\frac{\pi D^2}{4} = \pi(R + r)L + \frac{\pi d^2}{4}$$

$$D^2 = 4(R + r)L + d^2$$

or $D = \sqrt{4(R+r)L + d^2} = \sqrt{4(60+15)\times 90 + 30^2}$

$= 167$ mm

If 30 mm diameter is non metal part (Generally it happens)

$$\frac{\pi D^2}{4} = \pi(R + r)L$$

$$D^2 = 4(R + r)L$$

or $D = 2\sqrt{(R+r)L} = 2\sqrt{(60+15)\times 90} = 164.32$ mm

Ans. None of the above (*)

Closest answer (c)

End of Solution

Q.3 The SQC chart based on Binomial distribution is

(a) p chart (b) c chart

(c) $\bar{X}$ chart (d) R chart

Ans. (a)

The SQC chart based on Bionomial distribution is p-chart.

End of Solution

Q.4 For a classical (Wilson) model of determining economic order quantity (EOQ), the carrying and ordering costs are C_r and C_o, respectively. For an annual demand D, the minimum yearly total inventory cost is

(a) $\sqrt{DC_0C_r}$ (b) $\sqrt{1.5DC_0C_r}$

(c) $\sqrt{2DC_0C_r}$ (d) $\sqrt{3DC_0C_r}$

Ans. (c)

End of Solution

Q.5 For the abrasive jet machining process, the ratio of abrasive volume to carrier gas volume is 0.25. Further, the ratio of abrasive density to carrier gas density is 25. The mass ratio of abrasive to the mixture of abrasive and carrier gas is_____(round off to 2 decimal places)

Ans. (0.86)

Given $\frac{V_a}{V_g} = 0.25$ and $\frac{\rho_a}{\rho_g} = 25$,

$$\frac{m_a}{m_a + m_g} = \frac{1}{1+\frac{m_g}{m_a}} = \frac{1}{1+\frac{V_g\rho_g}{V_a\rho_a}} = \frac{1}{1+\frac{1}{0.25\times 25}}$$

$= 0.862069 \simeq 0.86$

End of Solution

Q.6 The solution of $\int_1^a \int_1^b \frac{dxdy}{xy}$ is

(a) $\ln(ab)$ (b) $\ln(a/b)$
(c) $\ln(a) + \ln(b)$ (d) $\ln(a)\ln(b)$

Ans. **(d)**

$$= \int_1^a \frac{1}{y}(\ln x)_1^b dy$$

$$= (\ln b)(\ln y)_1^a = \ln b \cdot \ln a$$

End of Solution

Q.7 The link lengths of a planar four bar mechanism are *AB* = 100 mm, *BC* = 25 mm, *CD* = 75 mm and *DA* = 90 mm. For achieving the full rotation of both the input (crank) as well as the output (follower) links, the link that needs to be fixed is

(a) *AB* (b) *BC*
(c) *CD* (d) *DA*

Ans. **(b)**

End of Solution

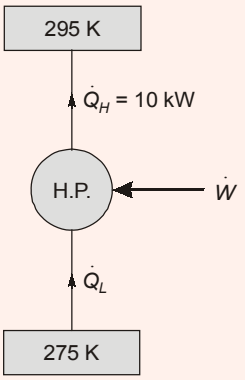
Q.8 A heat pump is to supply heat at the rate of 10 kW to a building to be maintained at 22°C. The outside temperature is 2°C. The minimum power (in kW) required to run the heat pump is_____(round off to 2 decimal places)

Ans. **(0.68)**

$$\text{COP} = \frac{\dot{Q}_H}{\dot{W}}$$

$$\dot{W} = \frac{10\,\text{kW}}{\text{COP}}$$

For, $\dot{W}$ to minimum COP must be maximum



$$\dot{W}_{min} = \frac{10\,\text{kW}}{(\text{COP})_{max}}$$

$$(\text{COP})_{max} = \frac{295}{295 - 275} = 14.75$$

$$\dot{W}_{min} = \frac{10\,\text{kW}}{14.75} = 0.6779 \simeq 0.68\ \text{kW}$$

End of Solution

Q.9 For a complex number $z = 1 - 4i$ with $i = \sqrt{-1}$, the value of $\left|\frac{z+3}{z-1}\right|$ is

(a) 0 (b) $\frac{1}{\sqrt{2}}$

(c) 1 (d) $\sqrt{2}$

Ans. **(d)**

$$\left|\frac{z+3}{z-1}\right| = \left|\frac{1-4i+3}{1-4i-1}\right| = \left|\frac{4-4i}{-4i}\right|$$

$$= \left|\frac{1-i}{-i}\right| = \left|\frac{1-i}{-i} \times \frac{i}{i}\right| = |i+1| = \sqrt{1+1} = \sqrt{2}$$

End of Solution

Q.10 Match the crystal structure in Column A with the corresponding packing fractions in Column B of the table

Column A		Column B	
1	Simple cubic	*P*	0.74
2	Hexagonal close-packed	*Q*	0.68
3	Body-centered cubic	*R*	0.52
4	Face-centered cubic		

(a) 1-P, 2-R, 3-Q, 4-Q (b) 1-R, 2-P, 3-R, 4-Q

(c) 1-R, 2-P, 3-Q, 4-P (d) 1-P, 2-R, 3-P, 4-Q

Ans. **(c)**

End of Solution

Q.11 If roots of the auxiliary equation of $\frac{d^2y}{dx^2} + a\frac{dy}{dx} + by = 0$ are real and equal, the general solution of the differential equation is

(a) $y = c_1e^{-ax/2} + c_2e^{ax/2}$ (b) $y = (c_1 + c_2x)e^{-ax/2}$

(c) $y = (c_1 + c_2\ln x)e^{-ax/2}$ (d) $y = (c_1\cos x + c_2\sin x)e^{-ax/2}$

Ans. **(b)**

Auxillary equation is $m^2 + am + b = 0$

Since roots are real and equal,

Roots must be $\frac{-a}{2}, \frac{-a}{2}$ $\left[\text{discriminant } b^2 - 4ac = 0\right]$

$\therefore$ Solution is

$$y = (c_1 + c_2x)e^{-\frac{a}{2}x}$$

End of Solution

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Q.12 One kilogram of air is compressed at constant temperature of 150°C until its volume is halved. Considering gas constant $R = 0.287$ kJ/kg-K for air,, magnitude of heat rejected (in kJ) in the compression process is_____(round off to 2 decimal places)

Ans. (84.15)

Treating Air as an ideal gas

$m = 1$ kg

Process : Constant temperature (At 150°C)

$$V_2 = \frac{1}{2}V_1 \quad [\text{Volume is decreased to half}]$$

$R = 0.287$ kJ/kg-K

Applying Ist law,

$$Q = \Delta U + W \qquad [\Delta U = 0 \text{ for ideal gas}]$$

$$Q = W$$

$$Q = mRT\ln\frac{V_2}{V_1} = 1\times 0.287\times 423\ln\left(\frac{1}{2}\right)$$

$Q = -84.148$ kJ $= -84.15$ kJ

Heat rejected = 84.15 kJ

End of Solution

Q.13 A warehouse has 1 loading dock and 3 persons for loading operations. The arrival rate of trucks follows Poisson distribution with a mean of 4 trucks/hour. The average loading time (by three persons together) per truck is exponentially distributed with a mean of 10 minutes. The charge of the trucks per hour and loading charges per person per hour are Rs.20 and Rs 6, respectively. The total cost (in Rs./hour) is_____.

Ans. (58)

$\lambda = 4$ trucks/hour

$\mu = 6$ trucks/hour

$$\rho = \frac{\lambda}{\mu} = \frac{4}{6} = \frac{2}{3}$$

$$L_S = \frac{\rho}{1-\rho} = \frac{2/3}{1-\frac{2}{3}} = \frac{2/3}{1/3}$$

$L_S = 2$

Total cost per hour = Charge for truck/hour + Loading charges/hour

Total cost per hour = $2 \times 20 + 3 \times 6$

$= 40 + 18 = ₹58$ per hour

End of Solution

Q.14 The capacity of a passenger airline is expressed in terms of

(a) available seats (b) available miles

(c) available sectors (d) available seat miles

Ans. **(d)**

Available Seat Miles (ASMs): A common industry measurement of airline output that refers to one aircraft seat flown one mile, whether occupied or not. An aircraft with 100 passenger seats, flown a distance of 100 miles, generates 10000 available seat miles.

Average Aircraft Capacity: Average seating configuration of an airline's operating fleet. The measure is derived by dividing total available seat miles flown by the number of aircraft miles flown. It is important to understand the average aircraft size as it is an important determinant of employees needed to service the operation of a particular airline.

End of Solution

Q.15 The vector that is normal to the surface $2xz^2 - 3xy - 4x = 7$ at the point (1, –1, 2) is

(a) $2i - 3j + 8k$ (b) $2i + 3j + 4k$

(c) $7i - 3j + 8k$ (d) $7i - 5j + 8k$

Ans. **(c)**

Let the equation of surface be $\phi = 2xz^2 - 3xy - 4x - 7$

The normal to this surface is given by $\nabla\phi$

$$\therefore \quad \nabla\phi = i\frac{\partial\phi}{\partial x} + j\frac{\partial\phi}{\partial y} + k\frac{\partial\phi}{\partial z}$$

$$= i\left[2z^2 - 3y - 4\right] + j\left[-3x\right] + k[4xz]$$

$$(\nabla\phi)_{(1,\,-1,\,2)} = 7i - 3j + 8k$$

End of Solution

Q.16 For any real, square and non-singular matrix B, the $\det B^{-1}$ is

(a) zero (b) $(\det B)^{-1}$

(c) $-(\det B)$ (d) $\det B$

Ans. **(b)**

Since we have $\det B^{-1} = \dfrac{1}{\det B} = (\det B)^{-1}$

End of Solution

Q.17 A company has purchased an asset by investing Rs. 30000. The useful life of the asset is 5 years and it has no salvage value at the end of its useful life. The depreciation cost (in Rs.) for the 2nd year using sum-of-years-digit (SYD) method is

(a) 10,000 (b) 8,000

(c) 6,000 (d) 4,000

Ans. **(b)**

I - Initial cost

V - Salvage value

Total Depreciation = $I - V$

Total depreciation = 30000 – 0 = ₹30000

Depreciation rate for 2nd year.

$$dm = \frac{(n-m+1)}{\text{SOY(Sum of years digit)}}$$

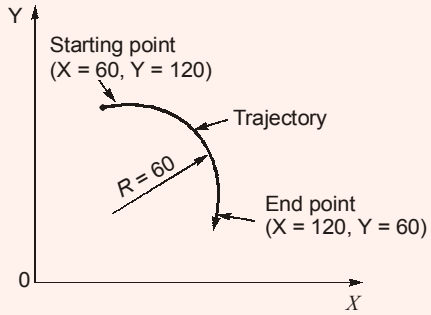
$$= \frac{(n-m+1)}{\frac{n(n+1)}{2}} = \frac{(5-2+1)}{\frac{5\times 6}{2}} = \frac{4}{15} \text{ (Depreciation rate for 2nd year)}$$

Depreciation amount for 2nd year = $dm \times (I - V)$

$$= \frac{4}{15} \times 30000 = ₹8000$$

End of Solution

Q.18 In a NC milling operation, the tool path is generated using absolute programing for the trajectory shown in the figure



The corresponding block of the NC program is

(a) G02 X 120.0 Y 60.0 R 60.0 (b) G02 X 60.0 Y 120.0 R 60.0

(c) G03 X 60.0 Y 120.0 R 60.0 (d) G03 X 120.0 Y 60.0 R 60.0

Ans. **(a)**

Direction clockwise

Final position - (120, 60)

Radius = 60

∴ Code - G02 *X*120 *Y*60 *R*60

End of Solution

Q.19 In a work study experiment, normal time was recorded as 140 s with a rating of 100%. Considering 2% allowance, the standard time (in s) is_____(round off to 1 decimal place)

Ans. **(142.9)**

$$ST = NT + \text{Allowances}$$
$$= NT + 0.2\,ST$$
$$ST = \frac{140}{0.98} = 142.9$$

End of Solution

Q.20 The average proportion non-conforming of 20 samples each of size 100 items is 0.12. The upper control limit for the relevant chart is_____(round off to 2 decimal places)

Ans. **(0.22)**

P - chart

$$UCL = \bar{P} + 3\sqrt{\frac{\bar{P}(1+\bar{P})}{n}} = 0.12 + 3\sqrt{\frac{0.12 \times 0.88}{100}}$$

$$UCL = 0.22$$

End of Solution

Q.21 A metallic rod of diameter d_0 is subjected to the tensile test. The engineering stress and the true stress at fracture are 800 MPa and 900 MPa, respectively. The ratio of the rod diameter at fracture d_f to the initial diameter d_0 is_____(round off to 2 decimal places)

Ans. **(0.94)**

$$\sigma_T = \sigma(1 + \epsilon)$$
or $$900 = 800(1 + \epsilon)$$
or $$1 + \epsilon = 1.125$$
$$\epsilon_T = \ln(1 + \epsilon)$$
$$\ln(1.125) = 2\ln\left(\frac{d_0}{d_f}\right)$$
or $$1.125 = \left(\frac{d_0}{d_f}\right)^2$$
$$\frac{d_f}{d_0} = \frac{1}{\sqrt{1.125}} = 0.9428 \simeq 0.94$$

End of Solution

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Q.22 In a typical turning tool life test, the following data are generated for tools A and B:

Tool name	Cutting speed (m/min)	Tool life (min)
A	200	20
B	150	58

Assuming the same tool life exponent for the tools, the value of constant in the Taylor's tool life equation (with cutting speed in m/min and tool life in min) is_____(round off to 2 decimal places)

Ans. **(449.33)**

$$V_1T_1^n = V_2T_2^n = C$$

$$200 \times 20^n = 150 \times 58^n = C$$

$$\frac{200}{150} = \left(\frac{58}{20}\right)^n$$

or $$\frac{4}{3} = (2.9)^n$$

or $$\ln\left(\frac{4}{3}\right) = n \ln 2.9$$

or $$n = \frac{\ln(4/3)}{\ln 2.9} = 0.2702$$

$$C = 200 \times 20^{0.2702} = 150 \times 58^{0.2702} = 449.33$$

End of Solution

Q.23 The process used for producing continuous insulation coating on an electrical wire is

(a) Extrusion (b) Injection molding
(c) Blow molding (d) Deep drawing

Ans. **(a)**

End of Solution

Q.24 REL chart is used in

(a) Quality management (b) Inventory management
(c) Facility management (d) Human resource management

Ans. **(c)**

REL chart is used in Facility management.

End of Solution

Q.25 The correct statement pertaining to the friction welding process is

(a) Heat affected zone is not formed
(b) Flashes are not produced
(c) Dissimilar materials cannot be joined
(d) Melting of the base material(s) is not involved

Ans. **(d)**

Friction welding:

- In friction welding one piece is rotated and the other is made to rub against it under an axial load resulting in increased friction, heat generation and joining when the pieces are brought to rest under enhanced axial load.
- There is no melting material. Narrow HAZ, if any.
- Disimilar metals can be joined.

End of Solution

Q.26 A process which is in a state of statistical control (within $\pm 3\sigma$) has an estimate of standard deviation (σ) 2 mm. The specification limits for the corresponding product are 120 ± 8 mm. When process mean shifts from 118 mm to 122 mm with no change in process standard deviation, the difference in process capability index C_{pk} is _____.

Ans. **(0)**

$$C_{pk} = \min (C_{pu}, C_{pl})$$

$$C_{pu} = \frac{USL - \mu}{3\sigma}$$

$$C_{pl} = \frac{\mu - LSL}{3\sigma}$$

Case I: Process mean is 118 mm.

$$C_{pu} = \frac{USL - \mu}{3\sigma} = \frac{128 - 118}{3 \times 2} = \frac{5}{3}$$

$$C_{pl} = \frac{\mu - LSL}{3\sigma} = \frac{118 - 112}{3 \times 2} = \frac{6}{6} = 1$$

$$C_{pk} = \min (C_{pu}, C_{pl})$$

$$C_{pk} = 1$$

Case II: Process mean is 122

$$C'_{pu} = \frac{USL - \mu'}{3\sigma} = \frac{128 - 122}{3 \times 2} = 1$$

$$C'_{pl} = \frac{\mu' - LSL}{3\sigma} = \frac{122 - 112}{3 \times 2} = \frac{5}{3}$$

$$C'_{pk} = \min(C'_{pu} \,\&\, C'_{pl})$$

$$C'_{pk} = 1$$

$$\text{Change} = C_{pk} - C'_{pk} = 0$$

End of Solution

Q.27 The numerical value of the definite integral $\int_0^1 e^{-x}dx$ using trapezoidal rule with function evaluations at points x = 0, 0.5 and 1 is _____(round off to 3 decimal places)

Ans. (0.645)

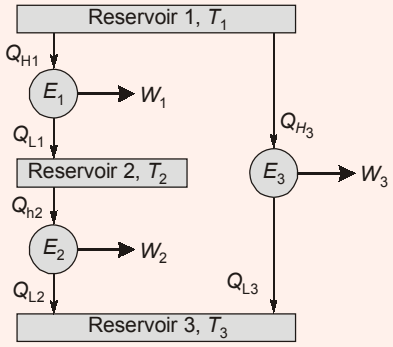
x	0	0.5	1
$f(x) = e^{-x}$	1	0.6065	0.3678

By Trapezoidal rule,

$$\int_0^1 e^{-x}dx = \frac{h}{2}[y_0 + y_2 + 2y_1] = \frac{0.5}{2}[1 + 0.3678 + 2(0.6065)]$$
$$= 0.6452 = 0.645$$

End of Solution

Q.28 Three Carnot engines E_1, E_2, E_3 operate as shown in the figure ($T_1 > T_2 > T_3$).



The efficiency of the engine E_3 in terms of the efficiencies η_1 and η_2 of the engines E_1 and E_2, respectively, is

(a) $\eta_1 + \eta_2$
(b) $\eta_1 + \eta_2 - \eta_1\eta_2$
(c) $1 - \eta_1 - \eta_2$
(d) $1 - \eta_1\eta_2$

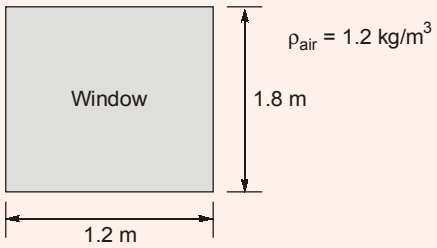
Ans. (b)

$$\eta_1 = 1 - \frac{T_2}{T_1} \qquad \eta_2 = 1 - \frac{T_3}{T_2}$$
$$\eta_3 = 1 - \frac{T_3}{T_1}$$
$$\frac{T_2}{T_1} = 1 - \eta_1 \qquad \frac{T_3}{T_2} = 1 - \eta_2$$
$$\frac{T_2}{T_1} \times \frac{T_3}{T_2} = \frac{T_3}{T_1} = (1-\eta_1)(1-\eta_2)$$
$$\eta_3 = 1 - (1-\eta_1)(1-\eta_2)$$
$$\eta_3 = 1 - [1 - \eta_2 - \eta_1 + \eta_1\eta_2]$$
$$\eta_3 = \eta_1 + \eta_2 - \eta_1\eta_2$$

End of Solution

Q.29 During a storm, the wind speed is 90 km/hr. In a high-rise building, there is a window of size 1.2 m × 1.8 m facing the storm on an upper floor. Neglecting the ground effects on wind speed and considering the density of air ρ_{air} = 1.2 kg/m^3, the force (in N) acting on the window due to the storm is _____.

Ans. (1620)



Force acting on window by air = Change in momentum

$$F = \dot{m}[V_1 - V_2]$$

$$F = \rho A V_1[V_1 - V_2] = \rho A V_1[V_1 - 0]$$

$$F = \rho A V_1^2 = 1.2 \times (1.2 \times 1.8) \times \left(90 \times \frac{5}{18}\right)^2$$

$$F = 1620 \text{ N}$$

End of Solution

Q.30 Considering included angle θ of the thread to be 60° using the Best-Wire method, the difference between the effective diameter (E) and the dimension under the wire (T) for M10 × 1.0 mm is closest to

(a) 0.289 (b) 0.578

(c) 0.867 (d) 0.982

Ans. (a)

$$E = T + P$$

$$E - T = P = \frac{p}{2}\cot\left(\frac{\alpha}{2}\right) - d\left\{\text{cosec}\left(\frac{\alpha}{2}\right) - 1\right\}$$

$$d = \frac{p}{2}\sec\left(\frac{\alpha}{2}\right) = \frac{1}{2}\sec\left(\frac{60}{2}\right) = 0.57735$$

$$E - T = \frac{1}{2}\cot\left(\frac{60}{2}\right) - 0.57735\left(\text{cosec}\frac{60}{2} - 1\right)$$

$$= 0.288675 \text{ mm}$$

End of Solution

Q.31 During a turning operation of a specific work material having shear strength of 220 MPa under orthogonal cutting condition, the process parameters are

Feed	0.2 mm/rev
Depth of cut	1 mm
Rake angle	−5°

Given chip thickness ratio as 0.5, friction angle as 49.2° and shear angle as 25.4°, the feed force (in N) is _____.

Ans. **(460.88)**

$$F_S = \tau_s \times \frac{bt}{\sin\phi} = 220\frac{N}{mm^2} \times \frac{1mm \times 0.2\,mm}{\sin 25.4^\circ}$$

$$= 102.58\ N$$

$$F_S = R\cos(\phi + \beta - \alpha)$$

$$102.58 = R\cos(25.4 + 49.2 + 5)$$

or $$R = 568.25$$

$$F_t = R\sin(\beta - \alpha) = 568.25\ \sin(49.2 + 5)$$

Feed force, $F_x = F_t = 460.88\ N$

End of Solution

Q.32 A thin walled cylindrical pressure vessel with an inside diameter of 300 mm and wall thickness of 3 mm is subjected to an internal gauge pressure of 1.5 MPa. The maximum shear stress (in MPa) at a point located on the inner surface of the pressure vessel is_____.

Ans. **(37.5)**

$$\text{Maximum shear stress, } \tau_{max} = \frac{\frac{PD}{2t}}{2} = 37.5\ MPa$$

End of Solution

Q.33 An acceptance sampling plan is selected with sample size $n = 80$, acceptance number $c = 2$ for a lot size of 10,000 units. The probability of accepting the lot is based on Poisson distribution. Assuming rectification inspection, if incoming lot quality p is 0.03 and mean (λ) is 2.4, the average outgoing quality (AOQ) is closest to

(a) 0.0011 (b) 0.0087

(c) 0.0170 (d) 0.0338

Ans. **(c)**

Sample size, $n = 80$

Acceptance number, $C = 2$

Let, Size (N) = 10000 units

Incoming lot quality, $p = 0.03$

Mean, $\lambda = 2.4$

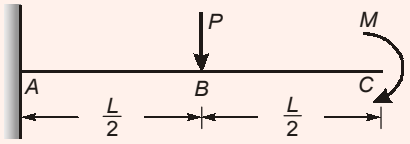
Average outgoing quality= ?

We know that,

$$AOQ = p.P_a$$
$$P_a = P(d = 0) + P(d = 1) + P(d = 2) = P(d \le 2)$$
$$P_{d=0} = {}^{80}C_0\,(p)^0\,(1-p)^{80}$$
$$P_{d=1} = {}^{80}C_1\,(p)^1\,(1-p)^{79}$$
$$P_{d=2} = {}^{80}C_2\,(p)^2\,(1-p)^{78}$$
$$P_a = 0.568$$
$$AOQ = 0.0170$$

End of Solution

Q.34 A uniform cantilever beam *ABC* of length *L* is subjected to a point load *P* at point *B* and a concentrated moment *M* at point *C* (as shown in figure). Let *E* be the Young's modulus of the beam material and *I* be the area moment of inertia of the beam's cross-section. Assuming the validity of the Euler-Bernoulli theory of slender beams, the downward deflection at point *C* is



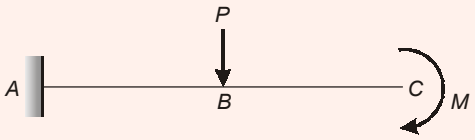
(a) $\frac{PL^3}{3EI}+\frac{ML^2}{2EI}$

(b) $\frac{PL^3}{24EI}+\frac{ML^2}{EI}$

(c) $\frac{PL^3}{48EI}+\frac{ML^2}{2EI}$

(d) $\frac{5PL^3}{48EI}+\frac{ML^2}{2EI}$

Ans. (d)



$$\Delta_C = \frac{P\left(\frac{L}{2}\right)^3}{3EI}+\frac{P\left(\frac{L}{2}\right)^2}{2EI}\cdot\frac{L}{2}+\frac{ML^2}{2EI}$$
$$= \frac{PL^3}{24EI}+\frac{PL^3}{16EI}+\frac{ML^2}{2EI}$$
$$= \frac{5PL^3}{48EI}+\frac{ML^2}{2EI}$$

End of Solution

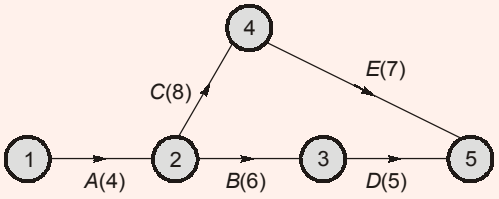
Q.35 A PERT project network consists of 5 activities *A* to *E*. The time estimates of these activities follow Beta-distribution. The predecessor-successor (P-S) relationships between the nodes and time estimates of activities are given in table.

Activity	$P-S$	Optimistic time (days)	Most likely time (days)	Pessimistic time (days)
A	1–2	2	4	6
B	2–3	4	5	12
C	2–4	5	8	11
D	3–5	2	5	08
E	4–5	4	6	14

The variance (in days) of the critical path is _____ (round off to 2 decimal places)

Ans. **(4.22)**

Activity	$\sigma^2 = \left(\frac{t_p - t_o}{6}\right)^2$	$t_E = \left(\frac{t_o + 4t_m + t_p}{6}\right)$
A	16/36	4
B	64/36	6
C	36/36	8
D	36/36	5
E	100/36	7



Critical path - 1 - 2 - 4 - 5

$$\sigma_{cp}^2 = \sigma_A^2 + \sigma_C^2 + \sigma_E^2$$
$$= \frac{16}{36} + \frac{36}{36} + \frac{100}{36} = \frac{152}{36} = 4.22$$

End of Solution

Q.36 The man-hours required (T_n) to manufacture the n^{th} unit in a plant is given by $T_n = T_1\, n^b$, where $b = -0.322$ at the 80% learning rate. If the manufacturing time for the first unit (T_1) is 80 man-hours, the total time (in man-hours) required to manufacture the first 4 units, at 80% learning rate, is

(a) 322.11 (b) 251.35
(c) 103.76 (d) 51.19

Ans. **(b)**

$$T_n = T_1 n^b$$
$$T_n = T_1\, n^{-0.322}$$
$$T_1 = 80 \text{ man-hours}$$
$$T_2 = T_1(2)^{-0.322} = 63.997 \text{ man-hours}$$
$$T_3 = T_1(3)^{-0.322} = 56.164 \text{ man-hours}$$
$$T_4 = T_1(4)^{-0.322} = 51.195 \text{ man-hour}$$
$$\text{Total time} = T_1 + T_2 + T_3 + T_4$$
$$= 251.356 \text{ man-hours}$$

End of Solution

Q.37 A company invests Rs. 50 thousand in assets. The initial investment is Rs. 30 thousand with two subsequent investments of Rs.10 thousand each at the end of 1st year and 2nd year. The useful life of the assets is 10 years with no salvage value at the end. If the interest rate is 10% and the minimum attractive rate of return (MARR) is 12%, the annual capital recovery and return (CRR) in thousands of Rs. is

(a) 8.38 (b) 7.06

(c) 5.74 (d) 3.10

Ans. **(a)**

Initial investment = ₹30000

After one year investment = ₹10000

After two year investment = ₹10000

Interest rate = 10%

Minimum attractive rate of return = 12%

Now, let annual capital recovery and return = ₹p.

We know that,

$$30+\frac{10}{(1.1)^1}+\frac{10}{(1.1)^2}-\left[\frac{P}{(1.12)^1}+\frac{P}{(1.12)^2}+.....+\frac{P}{(1.12)^{10}}\right]=0$$

$$47.3553719-\frac{P}{1.12}\left[\frac{1-\left(\frac{1}{1.12}\right)^{10}}{1-\frac{1}{1.12}}\right]=0$$

$$P=\left[\frac{47.3553719\times1.12\times0.12}{1.12\left(1-\frac{1}{1.12^{10}}\right)}\right]$$

P = ₹8.3811 thousand

P = ₹8.38 thousand

End of Solution

Q.38 An LPP is defined as

Minimize $z = 15x_1 + 12x_2$

subject to,

$$x_1 + 2x_2 \le 3$$
$$2x_1 - 4x_2 \le 5$$
$$x_1, x_2 \ge 0$$

The objective function of the dual of this LPP is

(a) Maximize $w = y_1 + y_2$ (b) Maximize $w = y_1 + 2y_2$

(c) Maximize $w = 2y_1 - 4y_2$ (d) Maximize $w = 3y_1 + 5y_2$

Ans. **(d)**

Maximize, $w = 3y_1 + 5y_2$

End of Solution

Q.39 A 100 mm long cylindrical workpiece of diameter 50 mm is reduced to 25 mm diameter using extrusion process. The flow curve for the metal has strength coefficient as K= 750 MPa and the strain hardening co-efficient is 0.15. Assuming no friction and no redundant work, the required ram pressure (in MPa) is closest to

(a) 164 (b) 364

(c) 428 (d) 950

Ans. **(d)**

$$L_0 = 100 \text{ mm}$$
$$d_0 = 50 \text{ mm}$$
$$d_f = 25 \text{ mm}$$
$$\epsilon_T = 2\ln\left(\frac{d_0}{d_f}\right) = 2\ln\left(\frac{50}{25}\right) = 1.3863$$
$$\bar{\sigma}_0 = \frac{K\epsilon_T^n}{1+n} = \frac{750\times(1.3863)^{0.15}}{1+0.15} = 684.92\,\text{MPa}$$
$$\sigma_E = 2\bar{\sigma}_0\ln\left(\frac{d_0}{d_f}\right) = 2\times 684.92\times\ln\left(\frac{50}{25}\right)$$
$$= 949.5 \text{ MPa}$$

End of Solution

Q.40 The sales data of a product for 5 years are

Year	2014	2015	2016	2017	2018
Sales (units)	280	268	259	270	287

Assume the forecast for the year 2014 as 260 units. Using an exponential smoothing method with smoothing constant α = 0.5, the sales forecast (units) for the year 2019, is_____.

Ans. **(277)**

$$F_{n+1} = \alpha D_n + (1-\alpha)F_n$$
$$F_{2015} = 0.5\times D_{2014} + (1-0.5)\times F_{2014}$$
$$F_{2015} = 270 \text{ units}$$
$$F_{2016} = 0.5\times D_{2015} + (1-0.5)\times F_{2015}$$
$$F_{2016} = 269 \text{ units}$$
$$F_{2017} = 0.5\times D_{2016} + (1-0.5)\times F_{2016}$$
$$F_{2017} = 264 \text{ units}$$
$$F_{2018} = 0.5\times D_{2017} + (1-0.5)\times F_{2017}$$
$$F_{2018} = 267 \text{ units}$$
$$F_{2019} = 0.5\times D_{2018} + (1-0.5)\times F_{2018}$$
$$F_{2019} = 277 \text{ units}$$

End of Solution

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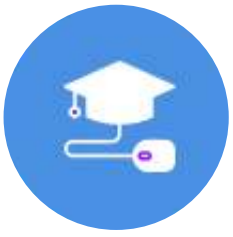

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Q.41 A sand casting process has a mold constant of 2 s/mm^2 and solidification exponent of 2. If the solidification time is to be doubled for a given unit volume of material, the corresponding reduction in the cast surface area (in %) is_____.

Ans. (29.28)

$$t_s = k\left(\frac{V}{A}\right)^n$$

Solidification factor (k) = 2 sec/mm^2

$n = 2$

$$t_{s1} = k\left(\frac{V}{A_1}\right)^2 \quad \text{... (i)}$$

$$t_{s2} = k\left(\frac{V}{A_2}\right)^2 \quad \text{... (ii)}$$

Volume (V) = 1 (unit volume)

and $t_{s2} = 2t_{s1}$

$$\frac{t_{s1}}{t_{s2}} = \frac{2\left(\frac{V}{A_1}\right)^2}{2\left(\frac{V}{A_2}\right)^2}$$

$$\frac{t_{s1}}{2t_{s1}} = \frac{\left(\frac{1}{A_1}\right)^2}{\left(\frac{1}{A_2}\right)^2}$$

$$\frac{1}{2} = \left(\frac{A_2}{A_1}\right)^2$$

$$\Rightarrow \quad \frac{A_2}{A_1} = \frac{1}{\sqrt{2}}$$

$$\% \text{ Reduction in surface area} = \frac{A_1 - A_2}{A_1} = 1 - \left(\frac{A_2}{A_1}\right) = 1 - \frac{1}{\sqrt{2}} = \frac{\sqrt{2}-1}{\sqrt{2}}$$

$$= 0.2928 \text{ or } 29.28\%$$

End of Solution

Q.42 If the Laplace transform of $e^{\omega t}$ is $\frac{1}{s-\omega}$, the Laplace transform of $t\cosh t$ is

(a) $\frac{1+s^2}{(s^2-1)^2}$

(b) $\frac{st}{(s^2-1)}$

(c) $\frac{1-s^2}{(s^2-1)^2}$

(d) $\frac{1+s^2}{1-s^2}$

Ans. (a)

We have $L[\cos ht] = \dfrac{s}{s^2-1}$

$$L[t\cos ht] = \frac{-d}{ds}\left[\frac{s}{s^2-1}\right]$$

$$= -\left[\frac{(s^2-1)(1)-(2s)s}{(s^2-1)^2}\right] = \frac{1+s^2}{(s^2-1)^2}$$

End of Solution

Q.43 In a sine bar, let h denote height of slip gauge and l be the distance between the rollers. The relationship between error in angular measurement ($d\theta$) and errors in the slip gauge combination (dh) and in the spacing of the rollers (dl) is

(a) $d\theta = \sin\theta\left(\dfrac{dh}{h}-\dfrac{dl}{l}\right)$ (b) $d\theta = \cos\theta\left(\dfrac{dh}{h}-\dfrac{dl}{l}\right)$

(c) $d\theta = \tan\theta\left(\dfrac{dh}{h}-\dfrac{dl}{l}\right)$ (d) $d\theta = \cot\theta\left(\dfrac{dh}{h}-\dfrac{dl}{l}\right)$

Ans. (c)

$$\sin\theta = \frac{h}{l}$$

$$\ln(\sin\theta) = \ln(h) - \ln(l)$$

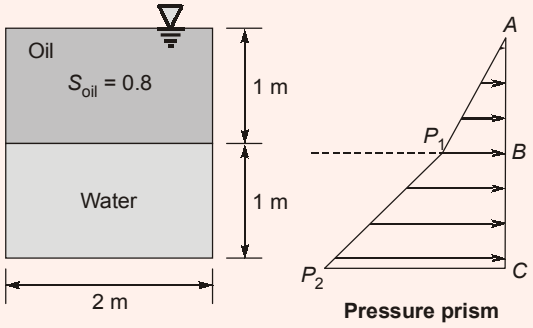
or $$\frac{\cos\theta}{\sin\theta}d\theta = \frac{dh}{h}-\frac{dl}{l}$$

or $$d\theta = \tan\theta\left(\frac{dh}{h}-\frac{dl}{l}\right)$$

End of Solution

Q.44 An open tank of 2 m × 2 m × 2 m is filled with layers of two fluids. Depth of each layer is one meter. The top layer is that of an oil of specific gravity 0.8. The bottom layer is of water. Consider the density of water ρ_w = 1000 kg/m^3 and acceleration due to gravity g = 9.8 m/s^2. Neglecting the effect of atmospheric pressure, the force (in N) exerted by the fluids on one of the side walls of the tank is_____

Ans. (33320)



Tank dimensions

Depth = 2 m, Width = 2 m, Length = 2 m

$w = \rho g$

Force on one side of tank = Volume of pressure prism

$$P_1 = (S_{oil})\ w \times 1 = 0.8w$$

$$P_2 = P_1 + w \times 1 = 0.8w + w = 1.8w$$

$$\text{Force, } F = \text{Width} \times \left[\frac{1}{2}(0.8w) \times 1 + \frac{1}{2}(1.8w + 0.8w) \times 1\right]$$

$$= 2\ [0.4w + 1.3w] = 3.4w$$

$$F = 3.4w = 3.4 \times 9800 = 33320\ \text{N}$$

End of Solution

Q.45 A firm, with a production target of 50,000 units/year, has the following data for the selection of a new location for its plant

Location	Fixed cost (Rs.)	Variable costs per unit (Rs.)
P	110,000	2
Q	95,000	2.5
R	80,000	3
S	75,000	3.5

The most economical location for the firm is

(a) *P* (b) *Q*

(c) *R* (d) *S*

Ans. (a)

$$TC_P = 110000 + 2x$$

$$TC_Q = 95000 + 2.5x$$

$$TC_R = 80000 + 3x$$

$$TC_S = 75000 + 3.5x$$

At 50000 units per year

TC_P = ₹210000 per year (minimum cost)

TC_Q = ₹220000 per year

TC_R = ₹230000 per year

TC_S = ₹250000 per year

Hence, *P* is the most economical location.

End of Solution

Q.46 A CO_2 laser in continuous mode is used for drilling a plate. The process parameters and their values are

Laser power intensity	1×10^8 W/mm^2
Vaporization energy	5×10^6 J/mm^3
Efficiency of the process	15%
Laser spot diameter	200 micrometer

The drilled depth (in mm) after 2 seconds is _____.

Ans. **(6)**

Laser spot diameter, $d = 200\ \mu m$

Laser power intensity, $I = 1 \times 10^8\ W/mm^2$

$$\text{Power given, } P = I \times \frac{\pi d^2}{4} = 1 \times 10^8 \frac{W}{mm^2} \times \frac{\pi}{4} \times (0.200)^2\ mm^2$$

$$= 3.1416 \times 10^6\ W$$

$$\text{Effective power, } P_e = P \times 0.15 = 3.1416 \times 10^6\ W \times 0.15$$

$$= 471.24\ kW$$

Effective energy in two seconds = 942.48 kJ

$$\text{Volume of metal vaporized} = \frac{942.48 \times 10^3\ J}{5 \times 10^6\ J/mm^3} = 0.1885\ mm^3$$

$$\frac{\pi d^2}{4} \times H = 0.1885$$

$$\frac{\pi (0.2)^2}{4} \times H = 0.1885$$

$$H = 6\ mm$$

End of Solution

Q.47 The heat transfer efficiency in arc welding of a plate using a current of 250 A at 20 V is 90%. The heat required to melt the material is 10 J/mm^3. If the cross-sectional area of the weld joint is 30 mm^2 and the travel speed is 5 mm/s, the melting efficiency (in %) is_____(round off to 2 decimal places)

Ans. **(33.33)**

Heat transfer efficiency of arc, $\eta_h = 0.9$

Current, $I = 250\ A$

Voltage, $V = 20\ V$

Heat required to melt the material (H_m) = 10 J/mm^3

Area of weld bead, $A = 30\ mm^2$

Welding speed, $v = 5\ mm/s$

$$\eta_m = \text{Melting efficiency} = \frac{H_m}{H_s} = \frac{H_m}{\frac{VI}{Av} \times \eta_h}$$

$$= \frac{10}{\frac{250 \times 20}{30 \times 5} \times 0.9} = 0.3333$$

$$\eta_m = 33.33\%$$

End of Solution

General Studies & Engineering Aptitude Batches for ESE 2020

(Preliminary Examination)

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Syllabus Covered

1. Current issues of national and international importance relating to social economic and industrial development.
2. Engineering Aptitude covering Logical reasoning and Analytical ability.
3. Engineering Mathematics and Numerical Analysis.
4. General Principles of Design, Drawing, Importance of Safety.
5. Standards and Quality practices in production, construction, maintenance and services.
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7. Basic of Project Management.
8. Basics of Material Science and Engineering.
9. Information and Communication Technologies (ICT) based tools and their applications in Engineering such as networking, e-governance and technology based education.
10. Ethics and values in engineering profession.

Course Duration

Regular Batches : 2.5 months
Weekend Batches : 4 months

Timings

Regular : 6 to 7 days a week and 4-6 hours a day
Weekend : Sat, Sun & public holiday, 8 hours each day

Teaching Hours

250-300 hours

Batch Type	Commencing Dates	Venue	Timing
Regular Batch	20th Feb, 2019	Ghitorni (Delhi)	8:00 AM to 12:00 PM
Weekend Batch	24th Feb, 2019	Ghitorni (Delhi)	8:00 AM to 5:00 PM
Weekend Batch	24th Feb, 2019	Noida Centre	8:00 AM to 5:00 PM

Fee Structure

Non-MADE EASY Students	Ex. MADE EASY Students Enrolled in Postal, Rank Improvement, Mains, GS, GATE, GATE + ESE Batches
₹ 25,000 • GS & Engg Aptitude Books will be issued.	₹ 18,000 • GS & Engg Aptitude Books will NOT be issued. • Interested students can avail books by paying the fee of Rs. 2,000/-

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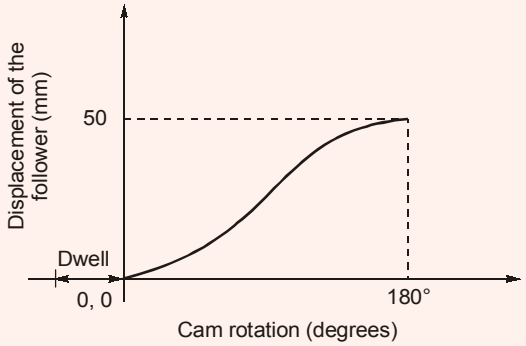
ADMISSION OPEN

Q.48 A cam is designed to achieve a simple harmonic motion of a flat-faced follower. Starting from the rest, the follower rises to the maximum height of 50 mm at 180° of cam rotation as shown in the figure.



If the cam rotates at a uniform angular speed of 100 rpm. the speed of the follower (in mm/s) at the instance when the cam rotates 45° from the initial position is_____.

Ans. **(185.118)**

Simple harmonic motion.

Stroke length, $S = 50 \text{ mm} = 0.050 \text{ m}$

Outstroke angle, $\theta_0 = 180° = \pi$

$N = 100 \text{ rpm}$

$$\omega = \frac{2\pi \times 100}{60} = 10.4719 \text{ rad/s}$$

Velocity of follower, $v_0 = \frac{S}{2} \times \frac{\pi\omega}{\theta_o} \sin\left(\frac{\pi\theta}{\theta_o}\right)$

At $\theta = 45° = \frac{\pi}{4}$

$$v_0 = \frac{50}{2} \times \left(\frac{\pi \times 10.4719}{\pi}\right) \sin\left(\frac{\pi \times \pi}{4\pi}\right)$$

$$v_0 = 185.118 \text{ mm/s}$$

End of Solution

Q.49 True centrifugal casting process in horizontal configuration is to be used for casting a metallic cylinder with outside diameter 0.275 m and inside diameter 0.250 m. If G-factor (ratio of centrifugal force experienced by the rotating cast metal to its weight) is 65 and acceleration due to gravity is 9.8 m/s^2, the minimum rotational speed (in rpm) required is closest to

(a) 325 (b) 650

(c) 975 (d) 1300

Ans. **(b)**

Outside diameter = 0.275 m

Inside diameter = 0.25 m

G-factor = 65

$g = 9.81\ \text{m/s}^2$
$N = ?$

$$\text{GF} = \text{G-factor} = \frac{F_c}{F_g} = \frac{\frac{mV^2}{R}}{mg} = \frac{V^2}{gR}$$

$$= \frac{R}{g}\left(\frac{2\pi N}{60}\right)^2$$

$$N = \frac{30}{\pi}\sqrt{\frac{g(GF)}{R}} = \frac{30}{\pi}\sqrt{\frac{9.81\times 65}{\left(\frac{0.275}{2}\right)}}$$

$N = 650.29$ rpm
$N = 650$ rpm

End of Solution

Q.50 If z is a complex variable with $i = \sqrt{-1}$, the length of the minor axis of an ellipse defined by $|z-(1+i)|+|z-(9+i)| = 10$ is _____.

Ans. **(6)**

Equation of ellipse in complex form is

$$|z - z_1| + |z - z_2| = 2a$$

where length of major axis is $2a$ and the two foci are z_1 and z_2
From the given equation, we have
Length of major axis, $2a = 10$
The two foci are (1, 1) and (9, 1)
$\therefore$ Center of the ellipse is (5, 1)
Also for an ellipse $a^2 - b^2 = c^2$
where c is distance from focus to center
Here $c = 4$
Now, $b^2 = a^2 - c^2$
$= 5^2 - 4^2 = 9$
$b = 3$
$\therefore$ Length of minor axis $= 2b = 6$

End of Solution

Q.51 The mean time to repair (MTTR) for a repairable system is 30 minutes. When maintenance time changes from 20 minutes to 40 minutes, the net increase in maintainability is closest to

(a) 0.15 (b) 0.25
(c) 0.45 (d) 0.60

Ans. (b)

$$M(t) = 1 - e^{-\mu t}$$

μ = Repair rate

$M(t)$ = Maintainability

MTTR = 30 minutes = 0.5 hour

$$\mu = \frac{1}{MTTR} = \frac{1}{0.5} = 2$$

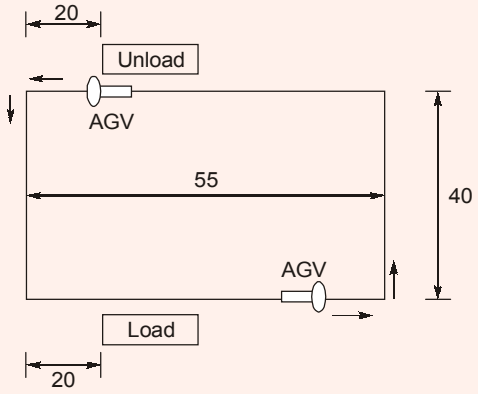
$$M_1(t) = 1 - e^{-2\times\frac{1}{3}} = 0.4866$$

$$M_2(t) = 1 - e^{-2\times\frac{2}{3}} = 0.7364$$

$$M_2(t) - M_1(t) = 0.2498 \approx 0.25$$

End of Solution

Q.52 The layout for an AGV system is shown in figure. The loading time is 0.5 minutes and the unloading time is also 0.5 minutes. All distances are in meters.



Considering a vehicle velocity of 50 m/min, availability of 0.95 and traffic factor of 0.9, the number of vehicles required to satisfy a demand of 50 delivery/hour is_____.

Ans. (5)

Travelling distance = (40 + 55) × 2 m = 190 m

Ideal time required for one job (only travelling)

$$= \frac{190\,\text{m}}{50\,\text{m/min}} = 3.8\,\text{min}$$

Considering traffic factor,

$$\text{Actual time required for one job} = \frac{\text{Ideal time}}{\text{Availability factor}} = \frac{3.8}{0.90} = 4.2222\,\text{min}$$

Adding loading and unloading time = 0.5 + 0.5 + 4.2222 = 5.2222 min

$$\text{Ideal delivery per AGV per hour} = \frac{60}{5.2222} = 11.489 \text{ per hour}$$

Considering availabiltiy factor,

Actual delivery per AGV per hour = 11.489 × 0.95 = 10.915 per hour

$$\therefore \quad \text{Number of AGV} = \frac{50}{10.915} = 4.58 \approx 5$$

End of Solution

Q.53 General solution of the Cauchy-Euler equation $x^2\frac{d^2y}{dx^2}-7x\frac{dy}{dx}+16y=0$ is

(a) $y = c_1x^2 + c_2x^4$ (b) $y = c_1x^2 + c_2x^{-4}$

(c) $y = (c_1 + c_2\ln x)x^4$ (d) $y = c_1x^4 + c_2x^{-4}\ln x$

Ans. **(c)**

Put $\ln x = t$ or $x = e^t$

So that $x\frac{dy}{dx} = \theta y$ where $\theta = \frac{d}{dt}$

$$x^2\frac{d^2y}{dx^2} = \theta(\theta - 1)y$$

Substitute in the given equation

$$\theta(\theta-1)y-7\theta y+16y = 0$$

$$\left[\theta^2-8\theta+16\right]y = 0 \rightarrow \text{Linear in } t$$

$\therefore$ A.E. is $m^2 - 8m + 16 = 0$

$$(m-4)^2 = 0$$

$\Rightarrow$ $m = 4, 4$

$\therefore$ Solution of A.E. is $y = (c_1+c_2t)e^{4t}$

$\therefore$ Solution of the given equation is,

$$y = (c_1 + c_2\ln x)x^4$$

End of Solution

Q.54 A 20 mm HSS drill with a point angle of 118° is used for drilling a through hole on a metallic plate of thickness 100 mm with a cutting speed of 333.33 mm/s and feed of 0.22 mm/rev. Assuming that the drill is touching the surface of the plate at the start, the drilling time (in s) is closest to

(a) 85 (b) 90

(c) 96 (d) 100

Ans. **(b)**

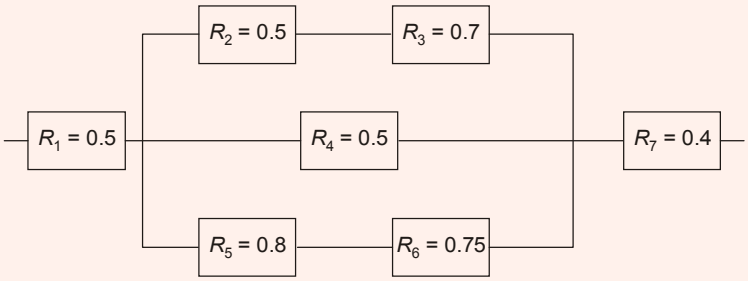
$$N = \frac{333.33}{\pi\times 20} = 5.305 \text{ rps}$$

Compulsory approach, $X = \frac{10}{\tan 59^\circ} = 6 \text{ mm}$

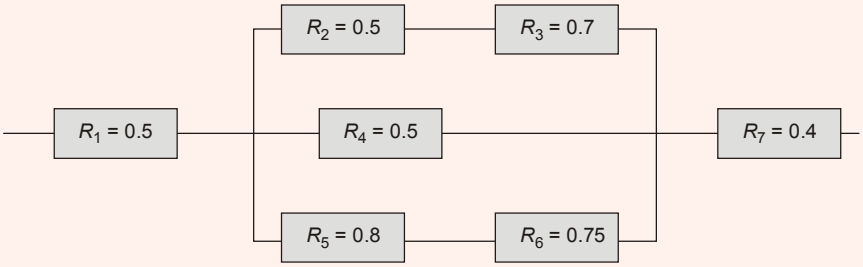
$$t_m = \frac{106}{0.22\times 5.308} = 90.77 \text{ s} \sim 90 \text{ s}$$

End of Solution

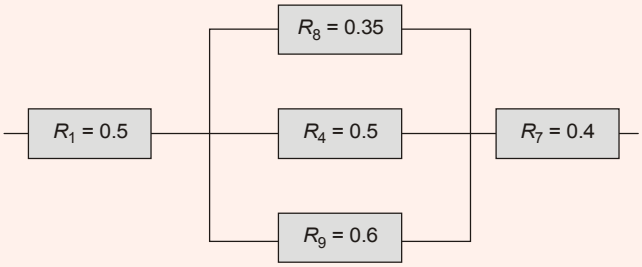
Q.55 A monitoring system has seven components. The reliability of each component is shown in the figure. The system reliability is _____ (round off to 2 decimal places)



Ans. (0.17)



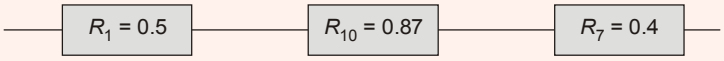
Step I:



$R_8 = R_2R_3 = 0.35$

$R_9 = R_5R_6 = 0.6$

Step II:



$$R_{10} = 1 - [(1 - R_8)(1 - R_4)(1 - R_9)]$$
$$= 1 - (0.65 \times 0.5 \times 0.4)$$
$$= 0.87$$

Step III:

$$R_s = R_1 \times R_{10} \times R_7 = 0.174$$

End of Solution

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