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GATE – 2019

Questions with Detailed Solutions

PRODUCTION AND INDUSTRIAL ENGINEERING

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GENERAL APTITUDE

01. Some students were not involved in the strike.

If the above statement is true, which of the following conclusions is/are logically necessary?

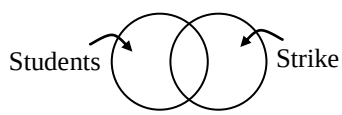
1. Some who were involved in the strike were students.
2. No students was involved in the strike.
3. At least one student was involved in the strike.
4. Some who were not involved in the strike were students.

(A) 1 and 2 (B) 3

(C) 4 (D) 2 and 3

01. Ans: (C)

Sol: From the given statement, the following venn-diagram can be formed



Some who were not involved in the strike were also students so, 4^{th} statement will be true logically.

$\therefore$ Hence, option (C) is correct.

End of Solution

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

(A) defeated (B) defeating

(C) defeat (D) defeatist

02. Ans: (A)

Sol: It is in the passive voice so had + been $+V_3$ form.

End of Solution

03. 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

03. Ans: (C)

Sol: As no two odd or even numbers are next to each other and second number from left is exactly half of the left most number, the only possibility is

Left most 10 5 __ __ __ __

Now, middle number is twice the right most number, thus __

Left most 10 5 4 __ 2 Right most

Therefore, 7 must be the 2nd number from the right

Left most 10 5 4 7 2 Right most

End of Solution

04. 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

04. Ans: (C)

Sol: Volume of cone = $\frac{1}{3}\pi r^2 h$

As per question, radius and height both increase by 10%

We know that, change in volume = Successive change of increase in radius and height.

$\therefore$ Successive change of 10%, 10% and 10% = successive of21% and 10% = 33.1%

Thus, change in volume = 33.1%

End of Solution

05. The fishermen, _____ the flood victims owed their lives, were rewarded by the government.

(A) whom (B) to which

(C) to whom (D) that

05. Ans: (C)

Sol: The fishermen, to whom the flood victims owed their lives, were rewarded by the government.

Objective case of who.

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

(A) 9 (B) 10

(C) 11 (D) 11.30

06. Ans: (B)

Sol: Relative speed of both trains 80 + 100 = 180 km/hr

Initially they are separated by distance = 540 km

$\therefore$ Time taken to meet = $\frac{540}{180} = 3\text{hrs}$

Thus, they meet 3hrs after 7AM i.e., 10 AM.

End of Solution

07. 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

07. Ans: (C)

Sol: As per the data given

→ "dhrupad" is associated with "baani"

→ "gayaki" is associated with "vocal"

→ "baaj" is associated with "instrumental"

→ "gharana" is associated with "lineage"

Thus, baaj, institution is not correct

Hence, option (C) is correct.

08. "I read somewhere that in ancient times the prestige of a kingdom 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

08. Ans: (D)

Sol: Head-hunter refers to the number of heads he could gather.

09. In a country of 1400 million population, 70% own mobile phones. Among the mobile phone owners, only 294 million access the internet. Among these 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

09. Ans: (A)

Sol: Population: 1400 million

Population with mobile phones = $\frac{70}{100}\times 1400 = 980$ million

Population with mobile phones who access internet = 294 million (given)

Population with mobile phones who access internet and buy goods from e-commerce portals = $\frac{50}{100}\times 294 = 147$ million

$\therefore$ Percentage of buyers in country = $\frac{147}{1400}\times 100 = 10.5\%$

10. 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 schemes to bring them on par with fixed deposit interest rates.

Which 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 sometime 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 by the Reserve Bank of India.

10. Ans: (D)

Sol: Last sentence refers to option (D).

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PRODUCTION AND INDUSTRIAL ENGINEERING

01. 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 capacity ratio C_r is _____ (round off to 3 decimal places).

01. Ans: 0.778

Sol: USL = 107 mm

LSL = 93 mm

σ = 3 mm

$$\text{Process capability ratio} = \frac{\text{USL} - \text{LSL}}{6\sigma}$$

$$= \frac{107 - 93}{6 \times 3}$$

$$= 0.778$$

End of Solution

02. 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

02. Ans: (D)

Sol: In friction welding melting of base materials is not involved.

End of Solution

03. REL chart is used in

(A) Quality management

(B) Inventory management

(C) Facility management

(D) Human resource management

03. Ans: (C)

Sol: REL chart is relationship chart used in facility management which locates departments based on relationship existing between them.

04. A metallic rod of diameter d_o 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_o is _____ (round off to 2 decimal places)

04. Ans: 0.942

Sol: Rod dia = d_o

Engineering = 800 MPa

Fracture stress = 900 MPa

True stress $\sigma = \bar{\sigma}\times(1+e)$

$\bar{\sigma}$ = Engg. stress

$900 = 800(1 + e)$

e = Engg. strain

e = 0.125

$$\frac{A_o}{A_f} = \frac{\ell_f}{\ell_0}$$

$$e = 0.125 = \frac{\ell_f}{\ell_0} - 1$$

$\Rightarrow l_f = 1.125$

$$\frac{A_0}{A_f} = 1.125$$

$$\Rightarrow \left(\frac{d_0}{d_f}\right)^2 = 1.125$$

$$\Rightarrow \left(\frac{d_0}{d_f}\right) = 1.0606$$

$$\therefore \quad \left(\frac{d_f}{d_0}\right) = 0.942$$

05. 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)

05. Ans: 0.862

Sol: Mixing ratio (MR) = $\frac{\text{Volume flow rate of abrasive particle}}{\text{Volume flow rate of carrier gas}}$

$$Mass\ ratio(\alpha) = \frac{Abrasive\ mass\ flow rate}{Combined\ flow rate\ of\ abrasive\ and\ carrier\ gas}$$

$$MR = \frac{V_a}{V_g} \text{ also } \alpha = \frac{M_a}{M_{a+g}} = \frac{\rho_a V_a}{\rho_a V_a + \rho_g V_g}$$

$$\text{Or, } \frac{1}{\alpha} = \frac{\rho_a V_a + \rho_g V_g}{\rho_a V_a} = 1 + \left(\frac{\rho_g}{\rho_a}\right)\left(\frac{V_g}{V_a}\right) = 1 + \frac{1}{25} \times \frac{1}{0.25}$$

$$\text{i.e. } \frac{1}{\alpha} = 1.16 \quad \text{or} \quad \alpha = 0.862$$

End of Solution

06. A company has purchased an asset by investing Rs.30,000. 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

06. Ans: (B)

Sol: $Depreciation\ in\ 2^{nd}\ year = \frac{Life\ remaining}{Sum\ of\ years} \times Cost$

$$= \left(\frac{4}{1+2+3+4+5}\right) \times 30{,}000$$

$$= \frac{4}{15} \times 30{,}000 = 8000/-$$

07. 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) $1/\sqrt{2}$

(C) 1 (D) $\sqrt{2}$

07. Ans: (D)

Sol: Now $\left|\frac{z+3}{z-1}\right| = \left|\frac{(1-4i)+3}{(1-4i)-1}\right| = \left|\frac{4-4i}{0-4i}\right|$

$$\Rightarrow \left|\frac{z+3}{z-1}\right| = \frac{|4-4i|}{|0-4i|} = \frac{\sqrt{16+16}}{\sqrt{0+16}} = \frac{\sqrt{32}}{4} = \frac{\sqrt{16\times 2}}{4}$$

$$\therefore \left|\frac{z+3}{z-1}\right| = \frac{4\sqrt{2}}{4} = \sqrt{2}$$

Hence, option (D) is correct.

End of Solution

08. 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)

08. Ans: 449.33

Sol: For Tool A

$V.T^n = C$

$200 \times 20^n = C$ -------- (1)

For Tool B

$150 \times 58^n = C$ --------- (2)

Equating (1) to (2)

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

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

$1.33 = 2.9^n$

$\ln 1.33 = n.\ 1n\ (2.9)$

$n = 0.27$

$\therefore\ 200 \times 20^{0.27} = C$

$C = 449.33$ m/min

09. The SQC chart based on Binomial distribution is

(A) p chart (B) c chart

(C) $\overline{X}$ chart (D) R chart

09. Ans: (A)

Sol: Accept/Reject criteria

'p' Chart follows binomial distribution

10. 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)

10. Ans: 84.148

Sol: Given:

M = 1 kg

$T_1 = T_2 = 150°C$

$$V_2 = \frac{V_1}{2}$$

R = 0.287 kJ/kgK

For isothermal process, heat transfer and work transfer both are same.

$$Q = W = P_1V_1\,\ell n\frac{V_2}{V_1}$$

$$= mRT_1\ell n\frac{V_2}{V_1}$$

$$= 1 \times .287 \times 423 \ell n \frac{V_1}{\frac{2}{V_1}}$$

Q = –84.148 kJ

-ve sign shows that heat is rejected from the system

Q = 84.148 kJ

End of Solution

11. Match the crystal structure in **Column A** with the corresponding packing fractions in **Column B** of the cable

	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

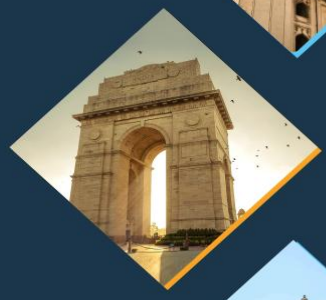
11. Ans: (C)

Sol:

Crystal structure	**Atomic packing factor**
Simple Cubic	0.52
Hexagonal Close Packed	0.74
Body Centered Cubic	0.68
Face Centered Cubic	0.74

ESE – 2019

STAGE-II (MAINS)



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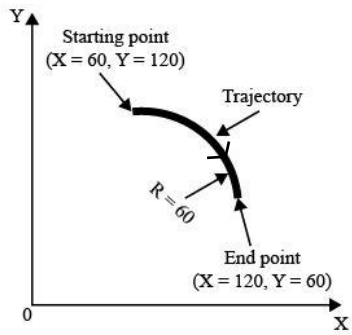
12. In a NC milling operation, the tool path is generated using absolute programming for the trajectory shown in the figure



The corresponding block of the NC program is

(A) G02 X120.0 Y60.0 R.60.0;

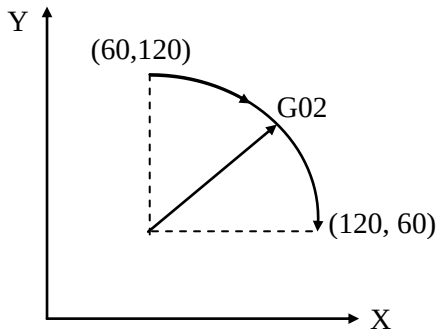
(B) G02 X60.0 Y120.0 R 60.0;

(C) G03 X60.0 Y120.0 R60.0;

(D) G03 X120.0 Y60.0 R60.0;

12. Ans: (A)

Sol:



G02 X60 Y120 X120 Y 60 R60

i.e., G02 X120.0 Y60.0 R 60.0;

End of Solution

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

(A) Extrusion

(B) Injection molding

(C) Blow molding

(D) Deep drawing

13. Ans: (A)

Sol: Wire coating is an extrusion process in which either the molten polymer is extruded continuously over an axially moving wire or wire is pulled through the extruded molten polymer.

14. 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)

14. Ans: 0.21

Sol: $UCL = \overline{P} + 3\sqrt{\frac{\overline{P}(1-\overline{P})}{n}}$

$= 0.12 + 3\sqrt{\frac{0.12 \times 0.88}{100}} = 0.2174$

15. 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)

15. Ans: (D)

Sol: $\int_1^a \int_1^b \frac{1}{xy} dxdy = \left(\int_{x=1}^a \frac{1}{x} dx\right)\left(\int_{y=1}^b \frac{1}{y} dy\right)$

$= (\log x)_1^a \cdot (\log y)_1^b$

$= [(\log a) - \log 1][\log b - \log 1]$

$= (\log a) \cdot (\log b)$

$\therefore$ Hence, option (D) is correct.

End of Solution

16. 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 _____.

16. Ans: 58

Sol: Arrival rate (λ) = 4 Truck/hr

Service rate by three person (μ) = 6 Truck/hr

$\mu > \lambda$ (system is balanced)

Truck charge = 20 Rs./hr

Loading charge = 6 Rs./person/hr.

Loading charges for all three person = 6×3 = 18 Rs./hr

Total charge in one hour = Loading crew cost + Cost of waiting time

= Number of loaders × Hourly wage rate + (Expected waiting time per truck, W_s)×(Expected arrival per hour, λ)

$= 6\times3+\frac{1}{6-4}\times4\times20$ = Rs. 58/hr

17. 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)

17. Ans: 0.678

Sol: For minimum power heat pump must be reversible

$$(COP)_{HP}=\frac{\dot{H}E}{\dot{W}_{in}}=\frac{T_h}{T_h-T_L}$$

$$\frac{10}{W_{in}}=\frac{295}{295-275}$$

$$W_{in}=0.678\ kW$$

End of Solution

18. 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)

18. Ans: 142.8

Sol: Standard time $=NT\times\left(1+\frac{RRA}{100}\right)=140\times\left(1+\frac{2}{100}\right)=142.8$ sec

End of Solution

19. 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) $y=(c_1+c_2 1nx)e^{-ax/2}$ (D) $y=(c_1\cos x+c_2\sin x)e^{-ax/2}$

19. Ans: (B)

Sol: The roots of the auxiliary equation of the sum differential equation $\frac{d^2y}{dx^2}+a\frac{dy}{dx}+by=0$ are real and equal.

If the roots are real & equal then the general solution of the given O.E must be in the form of

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

$\therefore$ Hence, option (B) is correct.

20. 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

20. Ans: (C)

Sol: Given surface is is $\phi = 2xz^2 + 3xy - 4x - 7$ & P = (1, –1, 2). The normal vector of $\phi(x, y, z)$ a point P is given by $(\nabla\phi)_P$.

Now, $\nabla\phi=(2z^2-3y-4)\bar{i}+(-3x)\bar{j}+(4xz)\bar{k}$

$\therefore (\nabla\phi)_P=(7)\bar{i}-3\bar{j}+8\bar{k}$

Hence, option (C) is correct.

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

(A) zero (B) $(\det \mathbf{B})^{-1}$

(C) –(det **B**) (D) det **B**

21. Ans: (B)

Sol: $\det B^{-1} = |B^{-1}|$

$\Rightarrow \det(B^{-1}) = |B|^{-1}$

$\therefore \det B^{-1}=\frac{1}{|B|}=(\det(B))^{-1}$

Hence, option (B) is correct.

22. For a classical (Wilson) model of determining economic order quantity (EOQ), the carrying and ordering costs are C_r and C_0, 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) $\sqrt{3DC_0C_r}$

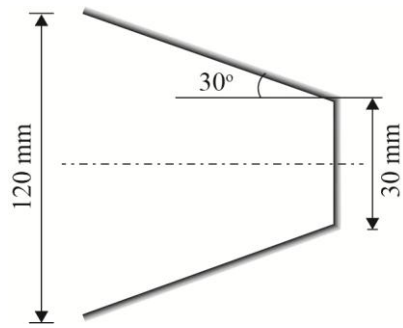
22. Ans: (C)

Sol: Minimum yearly inventory carrying cost = $\sqrt{2DC_rC_o}$

End of Solution

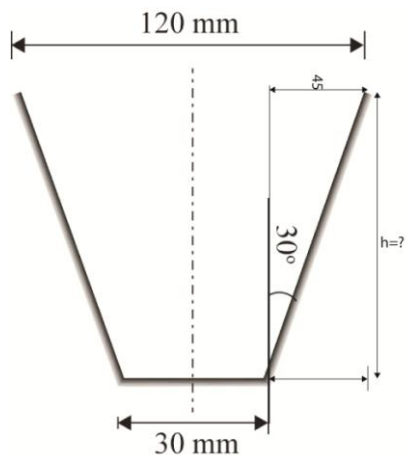
23. The end product obtained using spinning process is shown in the figure. The initial blank thickness is 2.5 mm. The blank diameter (in mm) is

(A) 75
(B) 105
(C) 150
(D) 210



23. Ans: (C)

Sol: $D=\sqrt{d_1^{\,2}+2(d_1+d_2)\times h}$



$\therefore \tan 30^0 = \frac{45}{h}$

b = 77.94 mm

$\therefore D=\sqrt{30^2+2(30+120)\times 77.94}$

D = 155.8 mm

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AIR 8  ROHIT BANSAL ME

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AIR 9  SOUVIK DEB ROY EE

AIR 9  ROOPESH MITTAL CE

AIR 10  PRATHAMESH E&T

AIR 10  MILAN KRISHNA EE

AIR 10  SRICHAND POONIYA CE

TOTAL SELECTIONS in Top 10	34

	TOP 10
E&T	10
EE	10
CE	8
ME	6

and many more...

24. The capacity of a passenger airline is expressed in terms of

(A) available seats (B) available miles

(C) available sectors (D) available seat miles

24 . Ans: (D)

Sol: Available seat miles (ASM) or Available seat kilometers (ASK) airline is passenger carrying capacity. It is equal to the number of seats available multiplied by the number of miles or kilometers flown.

End of Solution

25. 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

25. Ans: (B)

Sol:

Given :

S = 25 mm

L = 100 mm

P = 75

Q = 90

$\therefore$ L +S = 125

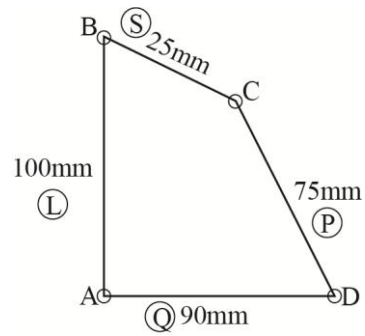
P +Q = 165

$\therefore$ (L+S) < (P +Q) – Class – I chain

As per Grashof's criterion,

For Double- Crank Mechanism, Fixed Link is

Shortest link i.e., BC



26. 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 (dθ) and errors in the slip gauge combination (dh) and in the spacing of the rollers $(d\ell)$ is

(A) $d\theta = \sin\theta\left(\frac{dh}{h} - \frac{d\ell}{\ell}\right)$

(B) $d\theta = \cos\theta\left(\frac{dh}{h} - \frac{d\ell}{\ell}\right)$

(C) $d\theta = \tan\theta\left(\frac{dh}{h} - \frac{d\ell}{\ell}\right)$

(D) $d\theta = \cot\theta\left(\frac{dh}{h} - \frac{d\ell}{\ell}\right)$

26. Ans: (C)

Sol: h = height of slip gauges

ℓ = distance between rollers

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

$\cos\theta\, d\theta = \frac{\ell dh - h d\ell}{\ell^2}$

$\cos\theta\, d\theta = \frac{dh}{\ell} - \sin\theta\frac{d\ell}{\ell} \qquad \left(\because \sin\theta = \frac{h}{\ell}\right)$

$d\theta = \frac{1}{\cos\theta}\left(\frac{dh}{\ell} - \sin\theta\frac{d\ell}{\ell}\right)$

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

End of Solution

27. 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 90 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

27. Ans: (B)

Sol: $T_n = T_1 n^b$

$T_2 = 80 \times 2^{-0.322} = 63.99$ hours

$T_3 = 80 \times 3^{-0.322} = 56.16$ hours

$T_4 = 80 \times 4^{-0.322} = 51.19$ hours

Total time = $T_1+T_2+T_3+T_4$ = 251.34 hours

End of Solution

28. 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 _____.

28 Ans: 810

Sol: Given data:

Wind speed, $V = 90\,\text{km/hr} = 90 \times \frac{5}{18} = 25\,\text{m/s}$

Window size = 1.2 m × 1.8 m

Window area = 1.2 m × 1.8 m^2

ρ_{air} = 1.2 kg/m^3

When the wind strikes the window, the pressure acting on wind side will be stagnation pressure as given by

$$P_0 = P_\infty + \frac{1}{2}\rho V^2$$

The pressure on window from inside will be P_∞.

Thus, the force acting on the window due to storm is

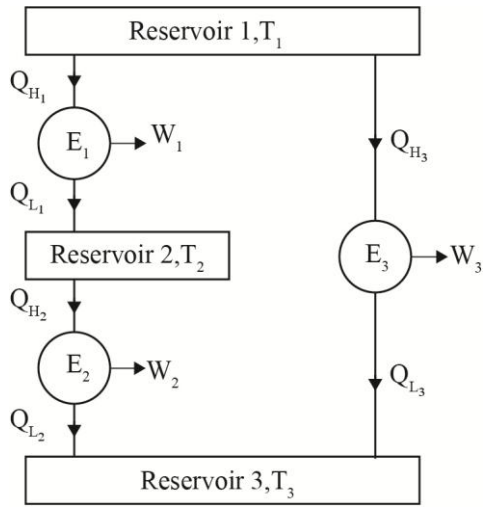
$$F = (P_0 - P_\infty) \times A_{window}$$

$$= \frac{1}{2}\rho V^2 \times A_{window}$$

$$= \frac{1}{2} \times 1.2 \times 25^2 \times 1.2 \times 1.8$$

= 810 N

29. 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) $1 - \eta_1\eta_2$

29. Ans: (B)

Sol:

$$\eta_1 = 1 - \frac{T_2}{T_1} \quad \rightarrow (1)$$

$$\eta_2 = 1 - \frac{T_3}{T_2} \quad \rightarrow (2)$$

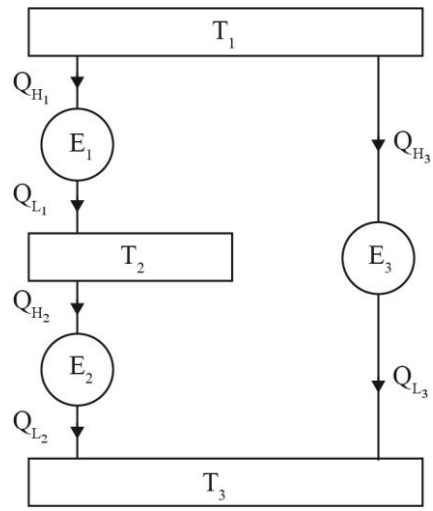
$$\eta_3 = 1 - \frac{T_3}{T_1} \quad \rightarrow (3)$$

$$\frac{T_3}{T_1} = \frac{T_3}{T_2} \times \frac{T_2}{T_1}$$

$$1 - \eta_3 = (1 - \eta_2)(1 - \eta_1)$$

$$1 - \eta_3 = 1 - \eta_1 - \eta_2 + \eta_1\eta_2$$

$$\eta_3 = \eta_1 + \eta_2 - \eta_1 . \eta_2$$



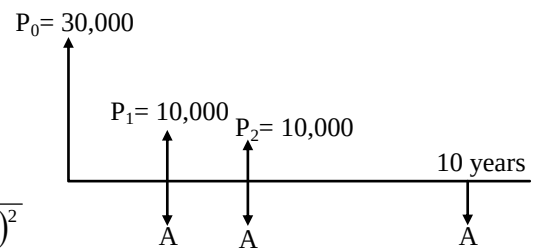
30. A company invests Rs. 50 thousand in assets. The initial investment is Rs. 30 thousand with two subsequent investments of Rs.10 thousand each at the end of 1st year and 2nd year. The useful life of the assets is 10 years with no salvage value at the end. If the interest rate is 10% and the minimum 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

30. Ans: (A)

Sol:



Interest rate = r = 10%

$$\text{Investmet present value} = P = P_0 + \frac{P_1}{(1+r)} + \frac{P_2}{(1+r)^2}$$

$$= 30{,}000 + \frac{10000}{1.1} + \frac{10{,}000}{(1.1)^2} = 30{,}000 + 8928.57 + 7971.94 = 47{,}355.37$$

$$\text{Capital recovery amount} = A = P\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right] = 47355.37\left[\frac{(0.12)(1.12)^{10}}{(1.12)^{10} - 1}\right] = \text{Rs. } 8381.15$$

End of Solution

31. 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 _____.

31. Ans: 6

Sol: Distance between foci = $|(1 + i) - (9 + i)| = 8 \le 10$

So, length of major axis is 10

Distance between foci = Length of major axis × eccentricity

$$8 = 10 \times e \Rightarrow e = \frac{8}{10}$$

Length of minor axis = Length of major axis × $\sqrt{1-e^2} = 10 \times \sqrt{1-\left(\frac{8}{10}\right)^2} = 6$

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	TOP 10	TOP 100
EC	9	74
EE	7	69
CE	7	42
ME	4	54
CSIT	6	31
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Vasthrapur-Gujarat-380015. Contact No : 079 4890 2228, 9160499966

32. An LPP is defined as

Minimize $z = 15x_1 + 12\,x_2$

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 $w = 3y_1 + 5y_2$

32. Ans: (D)

Sol: Constraints of Primal will become coefficients of objective function in dual and minimisation becomes maximisation.

$$Z_{max} = 3y_1 + 5y_2$$

End of Solution

33. A 20 mm HSS drill with a point angle of 118^o 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

33. Ans: (B)

Sol: Data given

D = 20 mm, $2\beta = 118°$, t = 100 mm, V = 333.33 mm/s

f = 0.22 mm/rev

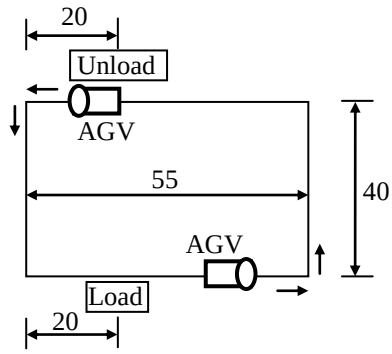
Compulsory approach = CAP = $\frac{D}{2}\cot\beta = \left(\frac{20}{2}\right)\cot 59° = 6$ mm

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

L = t + CAP = 100 + 6 = 106 mm

Time/hole = $\frac{L}{fN} = \frac{106}{0.22 \times 5.305} = 90.823$ sec

34. 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 _____.

34. Ans: 5

Sol: Speed = 50 m/min

Ideal time required for 1 truck to complete 1 cycle is

T_i = Loading time + Delivery time + Unloading time + Return time

$$= 0.5+\frac{(35+40+35)}{50}+0.5+\frac{(20+40+20)}{50}$$

= 4.8 min.

Considering traffic factor of 0.9 and availability factor 0.95, the actual time for one truck to complete one cycle is given by,

$$T_a = \frac{4.8}{0.9\times 0.95} = 5.614\,\text{min}$$

Number of delivers by 1 truck per 1 hour is given by,

$$d = \frac{60}{5.614} = 10.687 \text{ deliveries / hr}$$

Number of truck for 50 deliveries per hour is given by,

$$n = \frac{50}{d} = \frac{50}{10.687} = 4.678 = 5 \text{ trucks}$$

35. 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 _____.

35. Ans: 1.256

Sol: $d_{hole} = 200 \times 10^{-3}$ mm = 0.2 mm

Laser power intensity, $I = 1\times10^8$ W/mm^2

Efficiency of process, $\eta_{process} = 0.15$

Vaporization Energy = 5×10^6 J/mm^3

$$\text{Power (P)} = I\times\frac{\pi}{4}\times d^2$$

$$=1\times10^8\times\frac{\pi}{4}\times(0.2)^2$$

$$= 3.14 \text{ MW}$$

Effective power, P_e = Power × $\eta_{process}$ = 3.14 × 0.15 = 471.24 kW

Effective energy in two seconds = 942.48 kJ

$$\text{Volume of metal vaporized} = \frac{\text{Effective energy}}{\text{Vaporization Energy}} = \frac{942.48\times10^3}{5\times10^6} = 0.19 \text{ mm}^3$$

$\therefore$ The drilled depth after 2 seconds,

$$\frac{\pi}{4}d^2\times H = 0.19$$

$$\Rightarrow \frac{\pi}{4}\times(0.2)^2\times H = 0.19$$

$$\Rightarrow H = 6 \text{ mm}$$

36. A firm, with a production target of 50000 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

36. Ans: (A)

Sol: Total Cost = Fixed cost + Quantity×(Variable Cost)

$T = F + q.V$

$T_P = F_1 + q\ V_1 = 110,000 + 2\times 50,000 = 2,\ 10,\ 000/-$

$T_Q = F_2 + qV_2 = 95,000 + 2.5 \times 50,000 = 2,\ 20,000/-$

$T_R = F_3 + qV_3 = 80,000 + 3\times 50,000 = 2,\ 30,\ 000/-$

$T_S = F_4 + q\ V_4 = 75,000 + 3.5 \times 50,000 = 2,\ 50,\ 000/-$

37. Considering included angle θ of the thread to be 60^o 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

37. Ans: (A)

Sol: $2\theta = 60°$; M10 ×1.0 mm

P = 1 mm $\qquad D_w = \frac{P}{2}\sec\theta = \frac{1}{2}\sec 30 = 0.577$ mm

$PCD = X - D_w\ (1 - \sin\theta)$

$X - PCD = D_w (1 - \sin\theta) = 0.577 (1 - \sin 30) = 0.2885$

38. A 100 mm long cylindrical workpiece of diameter 50 mm is reduced to 25mm 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

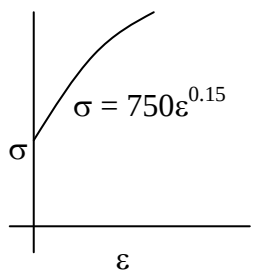
(A) 164 (B) 364

(C) 428 (D) 950

38. Ans: (D)

Sol: $P = \bar{\sigma}_o \ell n\left(\frac{A_o}{A_f}\right)$

$$\bar{\sigma}_o = \frac{\int_0^{\varepsilon_f} \sigma d\varepsilon}{\varepsilon_f}$$



$$\varepsilon_f = \ell n\left(\frac{\ell_f}{\ell_o}\right) = -2\ell n\left(\frac{d_f}{d_o}\right) = -2\ell n\left(\frac{50}{100}\right) = 1.386$$

$$\bar{\sigma}_o = \int_0^{1.386} \frac{750 \times \varepsilon^{0.15}}{1.386} d\varepsilon = \frac{750}{1.386 \times 1.15}(1.386)^{1.15} = 684.9\, MPa$$

$$P = 684.9 \ell n \frac{100^2}{50^2} = 949.47 \text{ MPa}$$

End of Solution

39. 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^o

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

ESE / GATE / PSUs - 2020 ADMISSIONS OPEN

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HYDERABAD - DSNR	GATE + PSUS – 2020	Regular Batches	26th April, 11th, 25th May, 09th, 24th June, 8th July 2019
HYDERABAD - DSNR	ESE + GATE + PSUs - 2020	Regular Batches	21st March, 26th April, 11th, 25th May, 09th, 24th June, 8th July 2019
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HYDERABAD - DSNR	GATE + PSUs - 2020	Morning/Evening Batch	24th February 2019
HYDERABAD - DSNR	ESE – 2019 STAGE-II (MAINS)	Regular Batch	17th Feb 2019
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HYDERABAD - Abids	ESE + GATE + PSUs - 2020	Morning Batch	24th February 2019
HYDERABAD - Abids	ESE – 2019 STAGE-II (MAINS)	Regular Batch	17th Feb 2019
HYDERABAD - Abids	GATE + PSUs - 2020	Weekend Batch	24th February 2019
HYDERABAD - Abids	ESE+GATE + PSUs - 2020	Spark Batches	11th May, 09th June 2019
HYDERABAD - Kukatpally	GATE + PSUs - 2020	Morning/Evening Batch	24th February 2019
HYDERABAD - Kukatpally	GATE + PSUS – 2020	Regular Batches	17th May, 1st, 16th June, 1st July 2019
HYDERABAD - Kukatpally	GATE + PSUs - 2020	Short Term Batches	29th April, 6th, 11th, 18th May 26th May, 2nd June, 2019
HYDERABAD - Kothapet	ESE + GATE + PSUS – 2020	Regular Batches	21st March, 26th April, 11th, 25th May, 09th, 24th June, 8th July 2019
HYDERABAD - Kothapet	ESE+GATE + PSUs - 2020	Spark Batches	11th May, 09th June 2019
DELHI	ESE+GATE+PSUs - 2020	Weekend Batches	9th Mar 2019
DELHI	ESE+GATE+PSUs - 2020	Regular Evening Batch	18th Feb 2019
DELHI	ESE+GATE+PSUs - 2020	Regular Day Batch	11th May 2019
DELHI	ESE+GATE+PSUs - 2020	Spark Batch	11th May 2019
DELHI	GATE+PSUs - 2020	Short Term Batches	11th, 23rd May 2019
BHOPAL	ESE+GATE+PSUs - 2020	Regular Day Batch	01st Week of June 2019
BHUBANESWAR	GATE+PSUs - 2020	Weekend Batch	16th Feb 2019
BHUBANESWAR	GATE+PSUs - 2020	Regular Batch	02nd Week of May 2019
CHENNAI	GATE+PSUs - 2020 & 21	Weekend Batch	16th Feb 2019
CHENNAI	GATE+PSUs - 2020	Regular Batch	02nd Week of May 2019
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BANGALORE	GATE+PSUs - 2020	Regular Batch	17th June 2019

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39. Ans: 460.892

Sol: Data given:

τ_u = 220 MPa, orthogonal cutting

f = 0.2 mm/sec, d = 1 mm

$\alpha = -5°$, r = 0.5, $\beta = 49.2°$, $\phi = 25.54°$

Cross section area of uncut chip = $t_1 \times b = f \times d = 0.2 \times 1 = 0.2 = A_o$

By taking $\tau_u = \tau$

$$\tau = \tau_u = \frac{F_s}{A} \times \sin\phi$$

$$F_s = \frac{\tau_u \times A}{\sin\phi} = \frac{220 \times 0.2}{\sin 25.4} = 102.58\,N$$

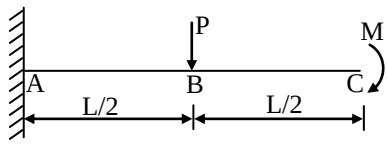
$$\frac{F_T}{\sin(\beta-\alpha)} = \frac{F_s}{\cos(\phi+\beta-\alpha)}$$

$$F_T = \frac{F_s \times \sin(\beta-\alpha)}{\cos(\phi+\beta-\alpha)}$$

$$= \frac{102.58 \times \sin(49.2+5)}{\cos(25.4+49.2+5)} = 460.892\ N$$

End of Solution

40. 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) $\frac{PL^3}{3EI} + \frac{ML^2}{2EI}$

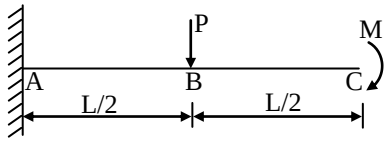
(B) $\frac{PL^3}{24EI} + \frac{ML^2}{EI}$

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

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

40. Ans: (D)

Sol:



Deflection at C = Deflection at C due to load P + Deflection at C due to moment M

= Deflection at B due to load 'P' + slope at B due to load 'P' ×length between B and C + Deflection at C due to moment M.

$$= \frac{P\left(\frac{L}{2}\right)^3}{3EI} + \frac{P\left(\frac{L}{2}\right)^2}{2EI} \times \frac{L}{2} + \frac{ML^2}{2EI}$$

$$= \frac{PL^3}{24EI} + \frac{PL^3}{16EI} + \frac{ML^2}{2EI} = \frac{5PL^3}{48EI} + \frac{ML^2}{2EI}$$

End of Solution

41. 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

41. Ans: (B)

Sol: MTTR = 30 min

Maintenance time T_1 = 20 min

Maintenance time T_2 = 40 min

Maintainability, $M(t) = 1 - e^{-(T/MTTR)}$

when $T = T_1 = 20$ min

$m(t) = 1 - e^{-(20/30)} = 0.4865$

when $T = T_2 = 40$ min

$M(t) = 1 - e^{-(40/30)} = 0.7364$

Net increasing maintainability = 0.7364 – 0.4865

= 0.2499 ≈ 0.25

42. A Process which is in a state of statistical control (within ± 3σ) 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_____.

42. Ans: 0

Sol: $C_{pk} = \min\left[\frac{USL-\mu}{3\sigma}, \frac{\mu-LSL}{3\sigma}\right]$

USL = 128 mm

LSL = 112 mm

σ = 2 mm

When μ = 118 mm

$C_{pk} = \min\left[\frac{128-118}{3\times 2}, \frac{118-112}{3\times 2}\right]$

$C_{pk} = \min[1.67, 1] = 1$

When μ = 122 mm

$C_{pk} = \min\left[\frac{128-122}{3\times 2}, \frac{122-112}{3\times 2}\right]$

$C_{pk} = \min[1, 1.6671]$

Difference = 1 – 1 = 0

End of Solution

43. 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_____.

43. Ans: 29.3

Sol: k = 2 sec/mm^2; $t = k\left(\frac{V}{A}\right)^2$; $A \propto \frac{1}{\sqrt{t}}$

$\frac{A_2}{A_1} = \sqrt{\frac{t_1}{t_2}} = \frac{1}{\sqrt{2}} = 0.707 \Rightarrow (A_2 - A_1) = (1 - 0.707) = 0.293 = 29.3\%$

44. 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 _____.

44. Ans: = 37.5

Sol: Thin cylindrical pressure vessel.

$$\tau_{max} = \frac{PD}{4t}$$

Given:

p = 1.5 MPa

D = 300 mm

t = 3 mm

$$\tau_{max} = \frac{1.5 \times 300}{4 \times 3}$$

$\therefore \tau_{max} = 37.5$ MPa

End of Solution

45. 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).

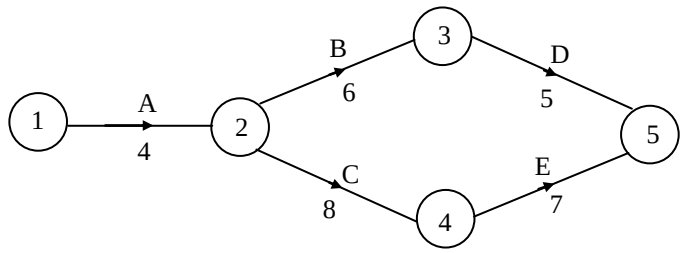
45. Ans: 4.22

Sol:

	T_o	T_m	T_P	T_e	σ	Var
A	2	4	6	4	2/3	4/9
B	4	5	12	6	4/3	16/9
C	5	8	11	8	1	1
D	2	5	8	5	1	1
E	4	6	14	7	5/3	25/9

Where $T_e = \frac{T_0 + 4T_m + T_p}{6}$

$\sigma = \frac{T_p - T_0}{6}$



Paths:

ABD 4 + 6 +5 = 15

ACE 4+8+7 = 19 ← Critical path

$(\text{Variance})_{CP} = (\text{Var})_A + (\text{Var})_C + (\text{Var})_E$

$= \frac{4}{9} + 1 + \frac{25}{9}$

$= \frac{4+9+25}{9} = \frac{38}{9} = 4.22$

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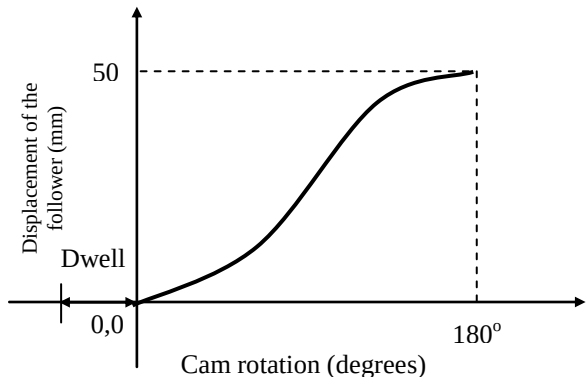
46. A cam is designed to achieve a simple harmonic motion of a flat-faced follower. Starting from the rest, the follower rises to the maximum height of 50 mm at 180^o of cam rotation as shown in the figure.



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^o from the initial position is _____.

46. Ans: 185.08

Sol: For SHM of flat faced follower

L = Lift = 50 mm

θ_R = Angle of rise = 180° = π rad

ω = 100 rpm = 10.47 rad/s

∴ Follower speed at θ = 45°

∴ Displacement of follower with SHM $y = \frac{L}{2}\left(1-\cos\frac{\pi\theta}{\theta_R}\right)$

∴ Velocity = $\frac{dy}{dt} = \frac{L}{2}\times\sin\frac{\pi\theta}{\theta_R}\times\frac{\pi\omega}{\theta_R}$

θ = 45° = $\frac{\pi}{2}$ rad

$$V = \frac{50\times\pi\times10.47}{2\times\pi}\times\sin\left(\frac{\pi\times\frac{\pi}{4}}{\pi}\right)$$

$$= 25\times1.47\times\sin\left(\frac{\pi}{4}\right) = 185.08$$

47. 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 $\alpha = 0.5$, the sales forecast (units) for the year 2019, is _____.

47. Ans: 277

Sol: $F_{15} = F_{14} + \alpha(D_{14} - F_{14})$

$= 260 + 0.5(280 - 260) = 270$

$F_{16} = F_{15} + \alpha(D_{15} - F_{15})$

$= 270 + 0.5(268 - 270) = 269$

$F_{17} = F_{16} + \alpha(D_{16} - F_{16})$

$= 269 + 0.5(259 - 269) = 264$

$F_{18} = F_{17} + \alpha(D_{17} - F_{17})$

$= 264 + 0.5(270 - 264) = 267$

$F_{19} = F_{18} + \alpha(D_{18} - F_{18})$

$= 267 + 0.5(287 - 267)$

$= 277$ Units

48. If the Laplace transform of $e^{\omega t}$ is $\frac{1}{s-\omega}$, the Laplace transform of *t cosht* 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) $\frac{1+s^2}{1-s^2}$

48. Ans: (A)

Sol: Given that $L\{e^{\omega t}\}=\frac{1}{s-\omega}$

Now, $L\{t.\cosh t\}=L\left\{t.\left(\frac{e^{t}+e^{-t}}{2}\right)\right\}$

$$=\frac{1}{2}L\{t.e^{t}\}+\frac{1}{2}L\{t.e^{-t}\}$$

$$=\frac{1}{2}(L\{t\})_{s\to s-1}+\frac{1}{2}(L\{t\})_{s\to s+1}$$

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

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

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

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

$$\therefore L\{t\cosh(t)\}=\frac{s^2+1}{(s^2-1)^2}$$

Hence, option (A) is correct.

End of Solution

49. 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 place).

49. Ans: 0.6452

Sol: Let $\int_a^b f(x)dx=\int_0^1 e^{-x}dx$ & h = 0.5 = 0.5 – 0 = 1 – 0.5

Then $f(x) = e^{-x}$, a = 0, b = 1

X	0	0.5	1
$Y = f(x) = e^{-x}$	1	0.6065	0.3675
	y_0	y_1	y_2

The formula of Trapezoidal rule is given by

$$\int_a^b f(x)dx \approx \int_a^b P(x)dx = \frac{h}{2}[(y_0 + y_2) + 2(y_1)]$$

$$\Rightarrow \int_0^1 e^{-x}dx \approx \int_0^1 P(x)dx = \frac{(0.5)}{2}[(1 + 0.3678) + 2(0.6065)]$$

$$\therefore \int_0^1 e^{-x}dx \approx \int_0^1 P(x)dx = \left(\frac{0.5}{2}\right)(2.58) = 0.6452$$

End of Solution

50. 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) $y = c_1x^4 + c_2x^{-4} \ln x$

50. Ans: (C)

Sol: Given $(x^2D^2 - 7xD + 16)y = 0$ .....(1), where $D = \frac{d}{dx}$

Let $x = e^x$ (or) $\log x = z$ & $xD = \theta$, $x^2D^2 = \theta(\theta - 1)$ ..... (2) where $\theta = \frac{d}{dz}$

Using (2), (1) becomes

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

$$\Rightarrow [\theta^2 - 8\theta + 16)y = 0$$

$$\Rightarrow f(\theta)y = 0, \text{ where } f(\theta) = \theta^2 - 8\theta + 16$$

Consider, A.E $f(m) = 0$

$$\Rightarrow m^2 - 3m + 16 = 0$$

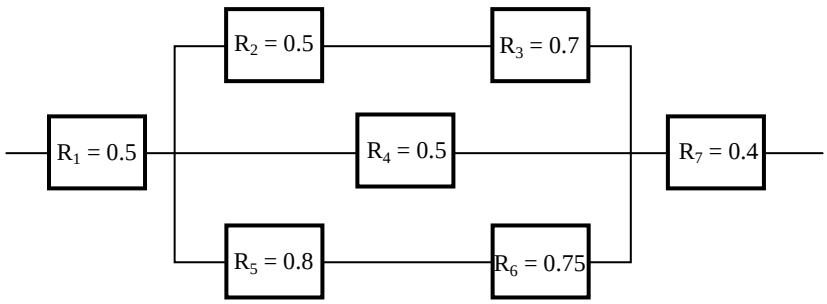
$$\Rightarrow m = 4, 4$$

$$\Rightarrow y_c = (c_1 + c_2 z)c^{4z} \Rightarrow y_c = (c_1 + c_2 \log x)x^4$$

$\therefore$ The general solution of (1) is $y = (c_1 + c_2 \log x)x^4$

Hence, option (C) is correct.

51. 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)



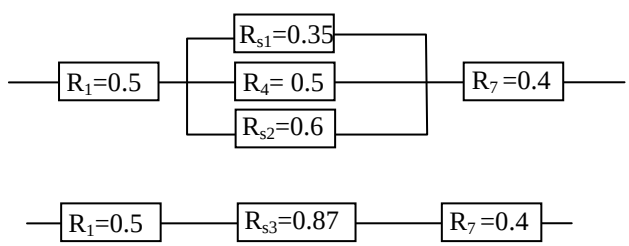
51. Ans: 0.174

Sol: $R_{S_1} = R_2 \times R_3 = 0.5 \times 0.7 = 0.35$

$R_{S_2} = R_5 \times R_6 = 0.8 \times 0.75 = 0.6$

$R_{s3} = 1-(1-R_{s1})(1-R_4)(1-R_{s2})$

$= 1-(1-0.35)(1-0.5)(1-0.6) \quad = 1-(0.65)(0.5)(0.4) = 0.87$



$R_s = R_1 \times R_{S_3} \times R_7$

$= 0.5 \times 0.87 \times 0.4 = 0.174$

End of Solution

52. 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).

52. Ans: 33

Sol: $\eta_h = 0.9$ $I = 250$ A $V = 20$ V

$u = 10$ J/mm^3 $A = 30$ mm^2 $v = 5$ mm/sec $\eta_m = ?$

$$v = \frac{\eta DVI}{uA}$$ D = 1 (not given)

$$5 = \frac{\eta \times 1 \times 20 \times 250}{10 \times 30}$$

$$\eta = \frac{5 \times 10 \times 30}{20 \times 250} = 0.3$$

$$\eta_h \times \eta_m = \eta$$

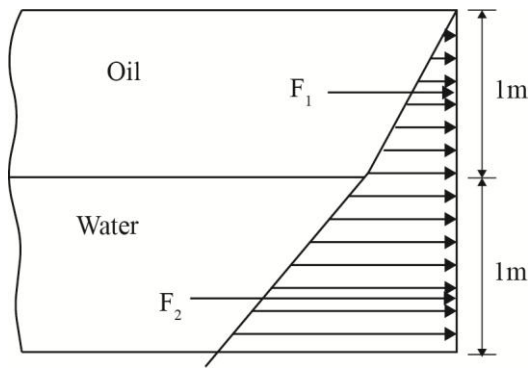
$$0.9 \times \eta_m = 0.3$$

$$\eta_m = \frac{0.3}{0.9} = 0.33 = 33\%$$

53. 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 $\rho_w = 1000$ 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 _____.

53. Ans: 33320

Sol:



$F = F_1 + F_2 = \{ P_{C.G}A\}_1 + \{P_{C.G} A\}_2$

$= (800\times9.8\times0.5)\,(1\times2) + (800\times9.8\times1 + 1000\times9.8\times0.5)\times(1\times2)$

$= 7840 + 25480$

$= 33, 320$ N

Method II:

F = Volume of pressure diagram

$$= \frac{1}{2}(800\times9.8\times1)\times2\times1+\frac{1}{2}(800\times9.8\times1+800\times9.8\times1+1000\times9.8\times1)$$

$= 7840 + 25480$

$= 33320$ N

54. True centrifugal casting process in horizontal configuration is to be using 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

54. Ans: (B)

Sol: N^2D = Constant

$$D = \frac{0.275+0.250}{2} = 0.2625$$

$$N^2D = \frac{a}{2\pi^2}$$

$$N^2D = \frac{65g}{2\pi^2}$$

$$N^2\times0.2625 = \frac{65\times9.81}{2\pi^2} \qquad N = 11.09 \text{ r.p.s}$$

$N = 665.599$ r.p.m ≈ 650 r.p.m

55. 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

55. Ans: (C)

Sol: N = 10,000

n = 80

C = 2

λ = 2.4

p = 0.03

$$P_a = e^{-\lambda} + \lambda e^{-\lambda} + \frac{\lambda^2}{2!}e^{-\lambda}$$

$$= e^{-\lambda}\left[1 + \lambda + \frac{\lambda^2}{2}\right]$$

$$= e^{-2.4}\left[1 + 2.4 + \frac{2.4^2}{1\times 2}\right]$$

$$= 6.28e^{-2.4} = 0.5697$$

$$AOQ = \frac{P_a(N-n)p}{N}$$

$AOQ = P_a \times p \rightarrow$ When N is very large when compared to P

= 0.5697×0.03 = 0.01709

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