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GATE - 2021

Questions with Detailed Solutions

PRODUCTION ENGINEERING

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GATE - 2021

PRODUCTION & INDUSTRIAL ENGINEERING

Questions with Detailed Solutions

06/02/21

Afternoon Session

SUBJECTWISE WEIGHTAGE

S. No.	NAME OF THE SUBJECT	Number of Questions
01	Engineering Mechanics	02
02	Strength of Materials	03
03	Theory of Machines & Vibrations	0
04	Machine Design	03
05	Fluid Mechanics & Turbo Machinery	04
06	Heat Transfer	01
07	Thermodynamics	02
08	IM & OR	15
09	Production	18
10	Engineering Materials	01
11	Engineering Mathematics	06
12	Verbal Ability & Numerical Ability	10
Total No. of Questions		**65**

Section : General Aptitude

01. The current population of a city is 11,02,500. If it has been increasing at the rate of 5% per annum, what was its population 2 years ago?
(a) 9.92.500 (b) 12,51,506
(c) 10.00,000 (d) 9.95.006

01. Ans: (c)

Sol: $P \times (105\%)^2 = 1102500$

$P = 1000000$

02. Nostalgia is to anticipation as_____is to_____ Which one of the following options maintains a similar logical relation in the above sentence?
(a) Past, future (b) Future, past
(c) Future, present (d) Present, past

02. Ans: (a)

Sol: Nostalgia (means excessively sentimental yearning for return to or of some past period) is to anticipation (means visualization of a future event or state)

03. p and q are positive integers and $\frac{p}{q} = \frac{q}{p} = 3$.

then. $\frac{p^2}{q^2} + \frac{q^2}{p^2} =$

(a) 11 (b) 7 (c) 3 (d) 9

03. Ans: (b)

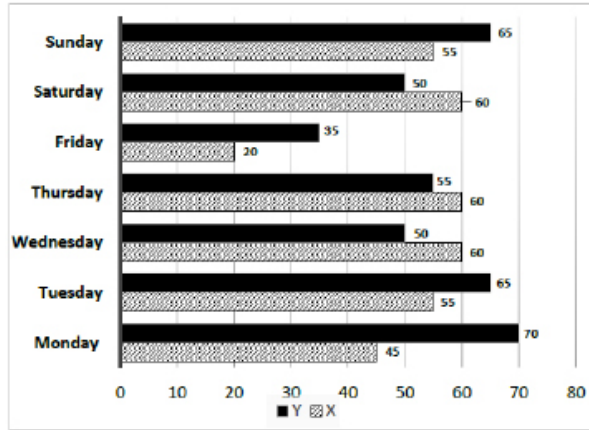
Sol: $\frac{p}{q} + \frac{q}{p} = 3$

$\left(\frac{p}{q} + \frac{q}{p}\right)^2 = 3^2$

$\frac{p^2}{q^2} + \frac{q^2}{p^2} + 2 = 9$

$\frac{p^2}{q^2} + \frac{q^2}{p^2} = 7$

04.



The number of minutes spent by two students, X and Y, exercising every day in a given week are shown in the bar chart above.
The number of days in the given week in which one of the students spent a minimum of 10% more than the other student, on a given day, is
(a) 5 (b) 4 (c) 7 (d) 6

04. Ans: (d)

Sol: Sunday 65 > 110 % (55) (Y > X)
Saturday 60 > 110 % (50) (X > Y)
Friday 35 > 110 % (20) (Y > X)
Wednesday 60 > 110 % (50) (X > Y)
Tuesday 65 > 110 % (55) (Y > X)
Monday 70 > 110 % (45) (Y > X)
Total 6 days, one student is 10% more than another student.

05. Given below are two statements and two conclusions.
Statement 1: All purple are green.
Statement 2: All black are green.
Conclusion I: Some black are purple.
Conclusion II: No black is purple.
Based on the above statements and conclusions, which one of the following options is logically CORRECT?

(a) Either conclusion I or II is correct.
(b) Only conclusion I is correct.
(c) Both conclusion I and II are correct.
(d) Only conclusion II is correct.

05. Ans: (a)

Sol:

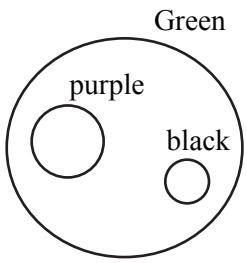


Diagram 1

No black is purple

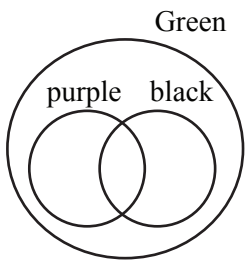


Diagram 2

Some black are purple

From above diagrams (1) & (2), it is clear that either conclusion I or II is correct.

06. Computers are ubiquitous. They are used to improve efficiency in almost all fields from agriculture to space exploration. Artificial intelligence (AI) is currently a hot topic. AI enables computers to learn, given enough training data. For humans, sitting in front of a computer for long hours can lead to health issues.

Which of the following can be deduced from the above passage?

(i) Nowadays, computers are present in almost all places.
(ii) Computers cannot be used for solving problems in engineering
(iii) For humans, there are both positive and negative effects of using computers.
(iv) Artificial intelligence can be done without data.

(a) (i) and (iii) (b) (ii) and (iv)
(c) (ii) and (iii) (d) (i). (iii) and (iv)

06. Ans: (a)

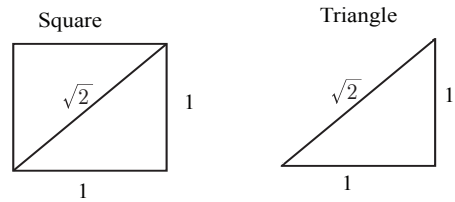
Sol: The passage deduces that computers are present every where and they have both positive and negative effects on humans.

07. Consider a square sheet of side 1 unit. In the first step, it is cut along the main diagonal to get two triangles. In the next step. one of the cut triangles is revolved about its short edge to form a solid cone. The volume of the resulting cone, in cubic units, is_____

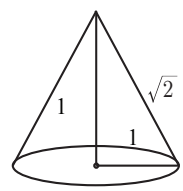
(a) $\frac{3\pi}{2}$ (b) 3π
(c) $\frac{\pi}{3}$ (d) $\frac{2\pi}{3}$

07. Ans: (c)

Sol:



Solid core formed by revolving triangle abouts its short edge



r = 1, h = 1

Volume of solid cone = $\frac{1}{3} \times \pi \times 1^2 \times 1 = \frac{\pi}{3}$

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08.Consider the following sentences;

(i) I woke up from sleep

(ii) I woked up from sleep.

(iii) I was woken up from sleep.

(iv) I was wokened up from sleep.

Which of the above sentences are grammatically CORRECT?

(a) (ii) and (iii) (b) (i) and (iv)

(c) (i) and (ii) (d) (i) and (iii)

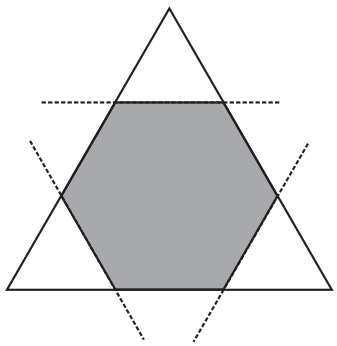
08. Ans: (d)

Sol: Wake pastense is woke and third form is woken

So, the verb forms are

V1	V2	V3
wake	woke	woken

09.



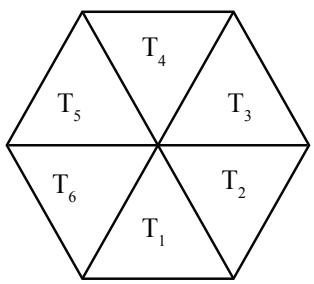
Corners are cut from an equilateral triangle to produce a regular convex hexagon as shown in the figure above.

The ratio of the area of the regular convex hexagon to the area of the original equilateral triangle is

(a) 4:5 (b) 5: 0 (c) 3:4 (d) 2:3

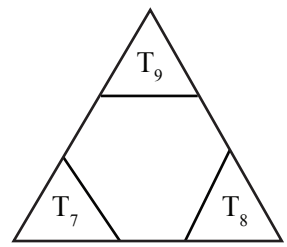
09. Ans: (d)

Sol:



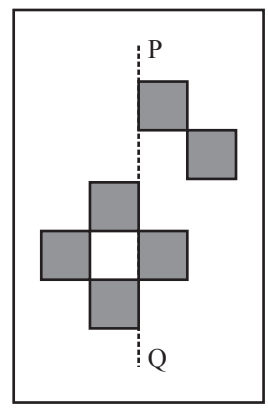
Area Hexagon = 6 Small Area Triangles

$T_7 = T_8 = T_9 = T_1 = T_2 = T_3 = T_4 = T_5 = T_6$ =Equal Areas



$$\frac{\text{Area of Hexagon}}{\text{Area of Original Triangle}} = \frac{6\,A}{9\,A} = \frac{2}{3}$$

10.

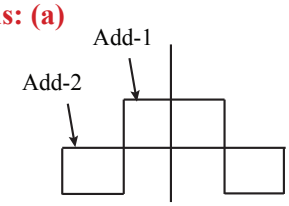


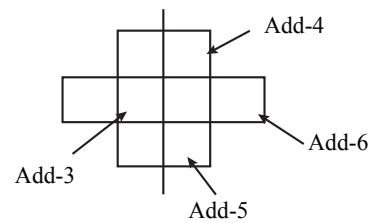
The least number of squares that must be added so that the line P-Q becomes the line of symmetry is_____

(a) 6 (b) 3 (c) 7 (d) 4

10. Ans: (a)

Sol:





6 squares to be added

PRODUCTION ENGINEERING

01. If $(3i+1)x+(4i+4)y+5=0$ with x, y being real and $i=\sqrt{-1}$, then x = _____[correct up one decimal place]

01. Ans: (2.5)

Sol: $(3i+1)x+(4i+4)y+5=0$

$3ix+x+4iy+4y+5=0$

$(x+4y+5)+i(3x+4j)=0$

$x+4y+5=0$

$3x+4y+0=0$

$-2x+5=0$

$x=\frac{5}{2}$

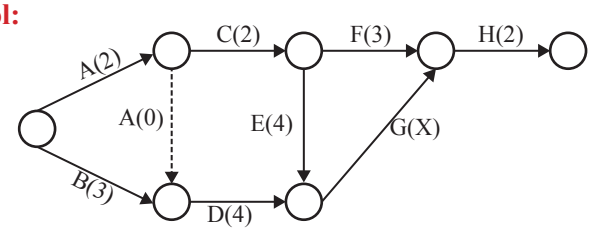
02. A project consists of eight activities. The time required for each activity and its immediate predecessor(s) are given in the table below.

Activity	Activity time (in days)	Immediate predecessor(s)
A	2	-
B	3	-
C	2	A
D	4	A, B
E	4	C
F	3	C
G	X	D,E
H	2	F,G

If the project completion time using critical path method (CPM) is 15 days, then value of X (in days) is ____. [in integer]

02. Ans: (5)

Sol:



Critical path = A-C-E-G-H

Critical Time = 15 Days

So, X = 15-2-2-4-2 = 5days

03. The dimensionless number defined by the ratio of inertial force to viscous force is called

(a) Mach number (b) Froude number

(c) Weber number (d) Reynolds number

03. Ans: (d)

Sol: Reynolds number is the ratio of inertial force to viscous force.

04. A 3 mm thick steel sheet, kept at room temperature of 30 °C, is cut by a fiber laser beam. The laser spot diameter on the top surface of the sheet is 0.2 mm. The laser absorptivity of the sheet is 50%. The properties of steel are density = 8000 kg/m^3, specific heat = 500 J/kg°C, melting temperature = 1530°C, and latent heat of fusion = 3×10^5 J/kg. Assume that melting efficiency is 100% and that the kerf width is equal to the laser spot diameter. The maximum speed (in m/s) at which the sheet can be fully cut at 2 kW laser power is_____

[*round off to 3 decimal places*]

04. Ans: (1.321)

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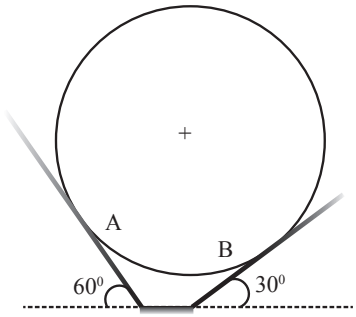
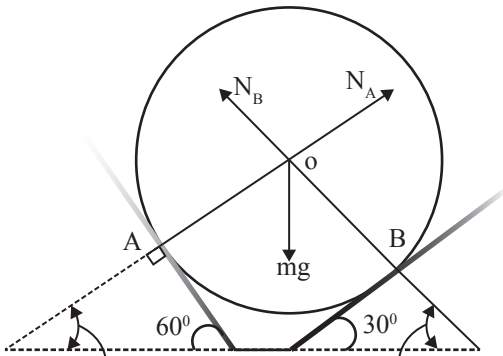
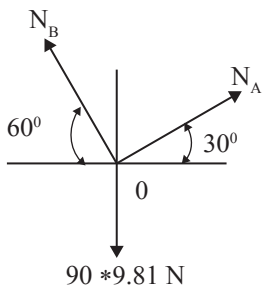
05. A 30 kg smooth, solid sphere rests on two frictionless inclines as shown in the figure. The magnitude of contact force in N acting at the point A is (take acceleration due to gravity g = 9.81 m^2s and consider both sphere and inclines to be rigid)_____ *[round off to 2 decimal places]*



05. Ans: (147.15)

Sol: FBD at centre of sphere:





Using lami's theorem,

$$\frac{30 \times 9.81}{\sin 90} = \frac{N_A}{\sin 150}$$

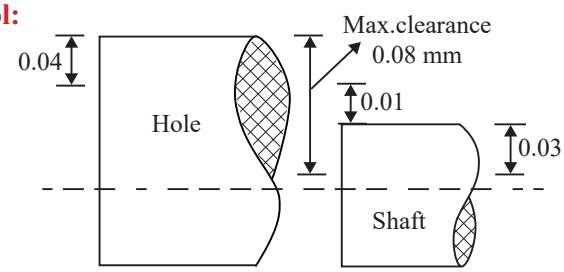
$\therefore N_A = 147.15$ N

06. In a shaft-hole assembly, the hole is specified as $30^{0.040}_{0.000}$ mm. The mating shaft has a clearance fit with minimum clearance of 0.01 mm. The tolerance on the shaft is 0.03 mm. The maximum clearance in mm between the hole and the shaft is

(a) 0.04 (b) 0.10 (c) 0.08 (d) 0.05

06. Ans: (c)

Sol:



07. An in-control process has an estimated standard deviation of 2 mm. The specification limits of the component being processed are 120 ± 8 num, When the process mean shifts to 118 mm. the values of the process capability indices. C_p and C_{pk}, respectively are.

(a) 1.000, 1.000 (b) 1.000, 1.667

(c) 1.333. 1.667 (d) 1.333, 1.000

07. Ans: (d)

Sol: $\sigma = 2$mm, USL = 128mm, LSL = 112mm

$\overline{X} = 118$mm

$$C_p = \frac{USL - LSL}{6\sigma} = \frac{128 - 112}{6 \times 2}$$

$$= \frac{16}{6 \times 2} = 1.33$$

$$C_{pk} = \min\left(\frac{USL - \overline{X}}{3\sigma}, \frac{\overline{X} - LSL}{3\sigma}\right)$$

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

$$= \min(1.67, 1)$$

$C_{pk} = 1$

08. A company manufactures two products P and Q with unit profit of 4 and 5, respectively. The production requires manpower and two kinds of raw materials R1 and R2. The following table summarizes the requirement and availability of resources.

Resource	Resource usage per unit of production		Amount of resource available
	P	Q	
man power	1	1	10
R1	1	2	18
R2	2	1	18

The maximum profit the company can make is

(a) 42 (b) 54 (c) 48 (d) 45

08. Ans: (b)

Sol: Maxz = 4P+5Q

subjected to

$P + Q \le 10$

$P + 2Q \le 18$

$2P + Q \le 18$

$P, Q \ge 0$

$\frac{P}{10} + \frac{Q}{10} \le 1$

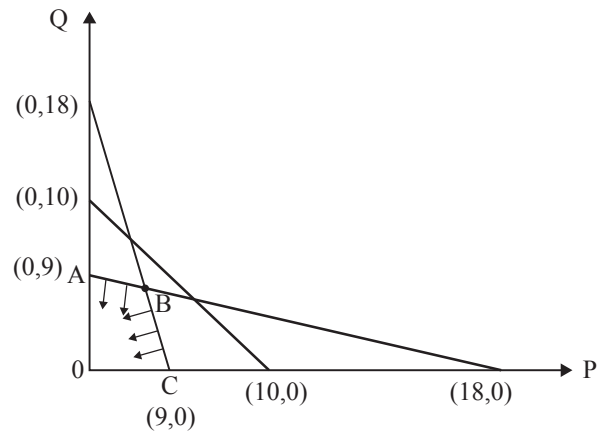
$\Rightarrow (10,0)(0,10) \ldots.(1)$

$\frac{P}{18} + \frac{Q}{9} \le 1$

(18,0) (0,9) ....(2)

$\frac{P}{9} + \frac{Q}{18} \le 1$

(9,0) (0, 18) ....(3)



$0(0,0) \rightarrow Z = 0$

$A(0,9) \rightarrow Z = 45$

$B(6,6) \rightarrow Z = 54$

$C(9,0) \rightarrow Z = 36$

Maximum Profit = 54

09. A retail chain company has identified four sites A, B, C and D to open a new retail store. The company has selected four factors as the basis for evaluation of these sites. The factors, their weights, and the score for each site are given in the following table.

Factor	Factor weight	Score for site (out of 100)			
		A	B	C	D
Average community income	0.4	60	70	80	50
Demand growth potential	0.1	30	80	50	40
Proximity to existing store	0.3	50	10	40	60
Availability of public transport	0.2	40	30	40	20

The site that should be selected to open the new retail store is

(a) Site A (b) Site D (c) Site B (d) Site C

09. Ans: (d)

Sol: Weighted Score of A $= (60 \times 0.4) + (30 \times 0.1) + (50 \times 0.3) + (0.2 \times 40) = 50$

Weighted Score of B $= (70 \times 0.4) + (80 \times 0.1) + (10 \times 0.3) + (30 \times 0.2) = 45$

Weighted Score of C $= (80 \times 0.4) + (50 \times 0.1) + (40 \times 0.3) + (40 \times 0.2) = 57$

Weighted score of D $= (50 \times 0.4) + (40 \times 0.1) + (60 \times 0.3) + (20 \times 0.2) = 46$

Best location is (c), it has highest weighted score.

10. Temperature field inside a sphere of radius R = 1 m with origin at its center is
$T(x, y, z) = 100 - 70x + 51y - 80z - 10x^2 - 20y^2 - 20z^2$.
If thermal conductivity of the sphere material is K = 50 W/m and Fourier law of heat conduction is valid, net heat leaving the sphere per unit time in W is_____
[round off to one decimal place]

10. Ans: (*)

11. A small capillary tube of 3 mm inner diameter is inserted into a fluid having density 900 kg/m^3, surface tension 0.1 N/m, and contact angle 30°. The rise in the height of fluid in the capillary tube due to surface tension is
(a) 89.1 mm (b) 128.3 nim
(c) 154.1 mm (d) 111.4 mm

11. Ans: (*)

Sol: Capillary rise in tube

$$h = \frac{4\sigma \cos\theta}{\rho.g.d}$$

$$h = \frac{4 \times 0.1 \times \cos 30°}{900 \times 9.81 \times 0.003} = 0.01307\text{m}$$

$$= 13.09 \text{ mm}$$

**No option matched.*

12. A company is producing a disc-shaped product of 50 mm thickness and 1.0 m diameter using sand casting process, The solidification time of the above casting process is estimated by Chorinov's equation $= B\left[\frac{V}{A}\right]^2$, where 8 is the mold constant, and I and A are the volume and surface area of the casting. respectively. It is decided to modify both the thickness and diameter of the disc to 25 mm and 0.5 m, respectively. maintaining the same casting condition. The percentage reduction in solidification time of the modified disc as compared to that of the bigger disc is
[round off to one decimal place]

12. Ans: (75)

Sol: $t_1 = B(M_1)^2 \rightarrow M_1 = \frac{d_1}{6} = \frac{1}{6} = 0.16$ m

$t_2 = B(M_2)^2 \rightarrow M_2 = \frac{d_2}{6} = \frac{0.5}{6} = 0.083$ m

$$\frac{t_1}{t_2} = \frac{M_1^2}{M_2^2} \Rightarrow \frac{t_1}{t_2} = \frac{0.16^2}{0.08^2} = 4$$

$t_1 = 4\, t_2 \Rightarrow t_2 = 0.25\, t_1$

Percentage reduction in solidification time $= \frac{t_1 - t_2}{t_1}$

$$= \frac{t_1 - 0.25\, t_1}{t_1} = 0.75$$

Percentage reduction = 75 %

13. A machine shop has received four jobs A, B. C and D for processing on a single CNC machine. All jobs are available for processing on the first day of the production schedule calendar, and processing times and due dates as applicable on the first day are given below. Using earliest due date rule, the average tardiness (in days) is_____[in integer]

Job	Processing time (in days)	Due date (day)
A	8	14
B	5	10
C	7	12
D	9	19

13. Ans: (4)

Sol: EDD Rule:

Job	In	Out	Due Date	Lateness	Tardiness
B	0	5	10	-5	0
C	5	12	12	0	0
A	12	20	14	6	6
D	20	29	19	10	10

$$\text{Avg. Tardiness} = \frac{\text{Total Tardiness}}{\text{no. of job}}$$

$$= \frac{10+6}{4} = 4$$

Note: Positive lateness is called tardiness.

14. The frequency of pulsing in a die-sinking electric discharge machine (EDM) is 10 kHz, The pulse off-time is set at 40 micro-seconds. The duty factor at this setting is

(a) 0.40 (b) 0.60 (c) 0.67 (d) 2.50

14. Ans: (b)

Sol: Given, $f = 10\text{ kHz} = 10\times 10^3\text{ Hz}$

Cycle time $= \frac{1}{10\times 10^3}\text{ sec} = \text{Total welding time}$

Pulse off time $= 40\times 10^{-6}\text{ sec} = RT$

$$\text{Duty factor (or) cycle} = \frac{AOT}{AOT+RT} = \frac{AOT}{TWT}$$

$$TWT = AOT + RT$$

$$\frac{1}{10\times 10^3} = AOT + 40\times 10^{-6}$$

$$\Rightarrow \quad AOT = 6\times 10^{-5}\text{ sec}$$

$$\text{Duty factor} = \frac{6\times 10^{-5}}{\frac{1}{10\times 10^3}} = 0.6$$

15. In an ideal Otto cycle. 800 kJ/kg is transferred to air during the constant volume heat addition process and 381 kJ/kg is removed during the constant volume heat rejection process. The thermal efficiency in % of the cycle is [*round off to one decimal place*]

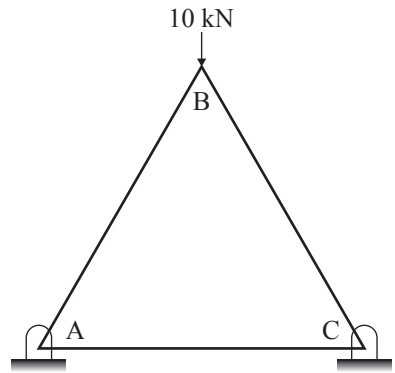
15. Ans: (52.4)

Sol: $\eta_{Th} = \frac{Q_s - Q_R}{Q_s} = 1 - \frac{Q_R}{Q_s}$

$$= 1 - \frac{381}{800} = 0.52375 \simeq 52.4\%$$

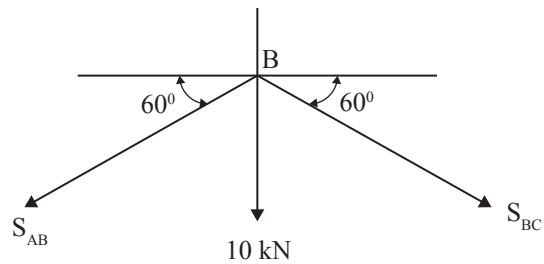
16. Consider the truss shown in the figure. The members AB, BC, and CA are all rigid and form an equilateral triangle. The contact between roller and ground at C is frictionless. If the self-weight of members is neglected, the force in member BC in N is (negative sign should be used if the force is compressive and positive if the force in the member is tensile)____

[round off to one decimal place]



16. Ans: (-5773.5)

Sol: FBD at joint B:



Using Lami's theorem:

$$\frac{10}{\sin 300} = \frac{S_{BC}}{\sin 30}$$

$$\therefore \quad S_{BC} = -5.7735\text{ kN}$$

$$= -5773.5\text{ N}$$

(Negative sign means compression)

AST

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17. In an arc welding process, the DC power source characteristic is linear with an open circuit voltage of 60 V and short circuit current of 600 A. The heat required for melting a metal during the welding is 10 J/mm^3, and the heat transfer and melting efficiencies are 80% and 25%, respectively. If the weld cross-sectional area of 20 mm^2 is made using the maximum are power, then the required welding speed in mm/s is_____[*round off to one decimal place*]

17. Ans: (144)

Sol: Open circuit voltage (V_o) = 60 V

Short circuit current (I_s) = 600 A

u = Energy required to melt unit volume = 10 J/mm^3

Heat transfer (η) = 80 %

Melting efficiencies (η_m) = 25%,

Cross-sectional area, A = 20 mm^2

Required welding speed, $(v) = \dfrac{\eta V I}{uA}$

$$= \frac{0.8 \times 60 \times 600}{10 \times 20} = 144 \text{ mm/s}$$

18. In a typical product development process under concurrent engineering approach, all elements of product life cycle from conception to disposal are considered at

(a) Disposal stage

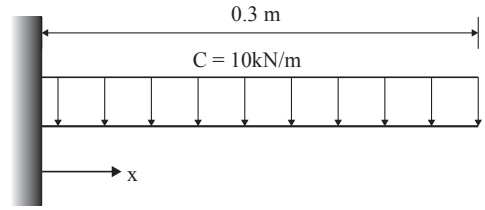
(b) Product design stage

(c) Process design stage

(d) Manufacturing stage

18. Ans: (b)

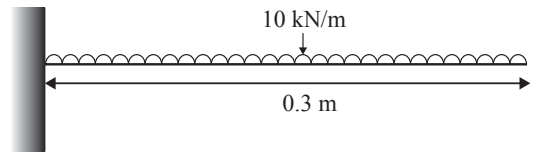
19. A cantilever beam of length 0.3 m is subjected to a uniformly distributed load C = 10 kN/m, as shown in the figure. The bending (flexural) rigidity of the beam is 5000 Nm^2. Neglecting the self-weight of the beam, the magnitude of beam curvature in m^{-1} at the fixed end is



(a) 0.05 (b) 0.09 (c) 0.02 (d) 1.10

19. Ans: (b)

Sol:



Given data,

Length of beam, L = 0.3 m,

EI = 5000 N.m^2

Maximum bending moment at fixed end = $\dfrac{wL^2}{2}$

$$= \frac{10 \times 10^3 (\text{N/m}) \times 0.3(\text{m}) \times 0.3(\text{m})}{2}$$

$$= 5 \times 0.3 \times 0.3 \times 10^3 \text{ N-m}$$

$\therefore$ curvature at fixed end = ρ

$$= \frac{1}{R} = \frac{M}{EI} = \frac{5 \times 0.3 \times 0.3 \times 10^3}{5000}$$

$$= 0.09 \text{ m}^{-1}$$

20. The minimum value of function f defined by $f(x, y, z) = x^2 + 5y^2 + 5z^2 - 4x + 40y - 40z + 300$ is_____, [in integer]

20. Ans: (136)

Sol: $f(x, y, z) = x^2 + 5y^2 + 5z^2 - 4x + 40y - 40z + 300.$

$f_x = 2x - y = 0 \Rightarrow x = 2$

$f_y = 10y + 40 = 0 \Rightarrow y = -4$

$f_z = 10z - 40 = 0 \Rightarrow z = 4$

Minimum and maximum value occurs at stationary points $f_x = 0, f_y = 0, f_z = 0$.

$$f(2, -4, 4) = 2^2 + 5(-4)^2 + 5(4)^2 - 4(2) + 40(-4) - 40(4) + 300$$

$$f(2, -4, 4) = 136$$

The minimum value of function $f(x, y, z) = 136$.

UPCOMING BATCHES @ HYDERABAD

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Batch Type	Timings	Batch Date	Duration	Venue & Streams
Regular	Daily 4 to 6 Hours	**2nd & 17th April 2021**	5 to 6 Months	Abids (CS&IT) Dilsukhnagar (EC, EE, IN) Kothapet (CE, ME, PI)
		1st & 17th May 2021		
		1st & 17th June 2021		

GATE + PSUs - 2022 (FLEXIBLE BATCHES)

Flexible Batches	Daily 6 to 8 Hours	**5th, 20th July 2021**	3 to 4 Months	Abids (CS&IT) Dilsukhnagar (EC, EE, IN) Kothapet (CE, ME, PI)
		4th, 18th August 2021		

GATE + PSUs – 2022 (SPARK BATCHES)

Spark	Daily 5 to 8 Hours	**17th May 2021**	5 to 6 Months	Abids (CE, ME, CS) Kukatpally (EC, EE)
		1st & 17th June 2021		

ESE + GATE + PSUs – 2022 (REGULAR BATCHES)

Regular	Daily 6 to 8 Hours	**2nd & 17th April 2021**	9 to 10 Months	Kukatpally (EC, EE) Abids (CE, ME)
		1st & 17th May 2021		
		1st & 17th June 2021		

ESE + GATE + PSUs – 2022 (SPARK BATCHES)

Spark	Daily 6 to 8 Hours	**17th May 2021**	9 to 10 Months	Kukatpally (EC, EE) Abids (CE, ME)
		1st & 17th June 2021		

21. A circular tank of 4 m diameter is filled up to a height of 3 m. Assuming almost steady flow and neglecting losses, the time taken in seconds to empty the tank through a 5 cm diameter hole located at the center of the tank bottom (take acceleration due to gravity $g = 9.81\ m/s^2$) is [*round off to the nearest integer*]

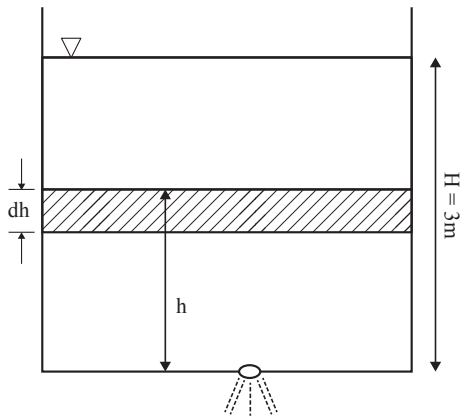
(a) 8097 (b) 5005

(c) 3154 (d) 1807

21. Ans: (b)

Sol: Given data: D = 4m; H = 3 m

d = 5 cm; $g = 9.81\ m/s^2$



$$dt = \frac{d\forall}{Q}$$

$$= \frac{-A_T dh}{c_d \times a\sqrt{2gh}}$$

- ve sign indicates that as time increases, h decreases.

$$\therefore \int_0^t dt = \int_0^H \frac{-A_T.dh}{C_d a\sqrt{2gh}}$$

Simplifying the above equation,

$$\therefore t = \frac{2A_T}{c_d a\sqrt{2g}}\sqrt{H}$$

$$t = \frac{2 \times \frac{\pi}{4}(4)^2}{(1)\left(\frac{\pi}{4}(0.05)^2\right)} \times \frac{\sqrt{3}}{\sqrt{2 \times 9.81}}$$

$$= \frac{2 \times 16}{(0.05)} \times \frac{\sqrt{3}}{\sqrt{2} \times 9.81} = 5005 \text{ sec}$$

22. A single point cutting tool with 15° orthogonal rake angle is used to machine a mild steel plate under orthogonal machining condition. The depth of cut (uncut thickness) is set at 0.9 mm. If the chip thickness is 1.8 mm, then the shear angle in degree is_____ [*round off to one decimal place*]

22. Ans: (29.0)

Sol: Given, $\alpha_0 = 15°$

$d = 0.9\ mm = t_0$

$t_c = 1.8\ mm$

$\phi = ?$

$$r = \frac{t_0}{t_c} = \frac{0.9}{1.8} = 0.5$$

$$\tan\phi = \frac{r.\cos\alpha_0}{1 - r\sin\alpha_0}$$

$$\tan\phi = \frac{0.5 \times \cos 15°}{1 - 0.5 \times \sin 15°}$$

$$\tan\phi = \frac{0.482}{0.870}$$

$$\phi = 29.04°$$

23. For a given process control chart, there are four rules for determining out-of-control state of the process which are being used simultaneously. The probability of Type-I error for the four rules are 0.005, 0.02, 0.03, and 0.05. Assuming independence of the rules, the probability of overall Type-I error when all the four rules are used simultaneously is

(a) 0.001 (b) 0.201

(c) 0.301 (d) 0.101

23. Ans: (d)

Sol: Overall Type -I error

$$= 1 - \left[(1 - 0.005)(1 - 0.02)(1 - 0.03)(1 - 0.05)\right]$$

$$= 0.101$$

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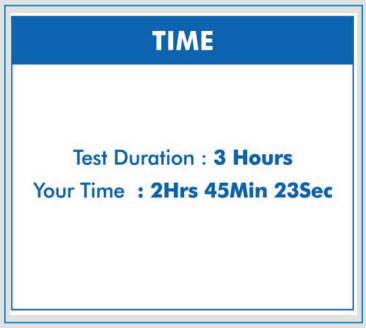
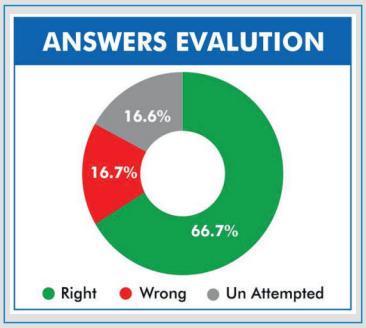
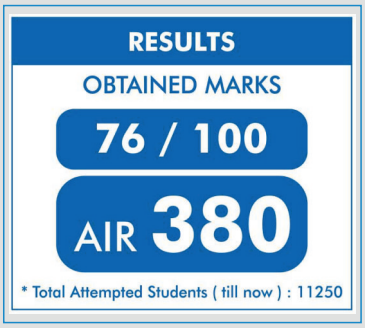
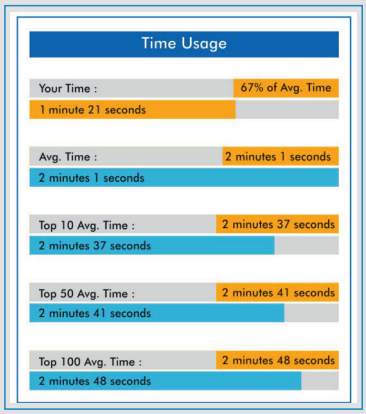
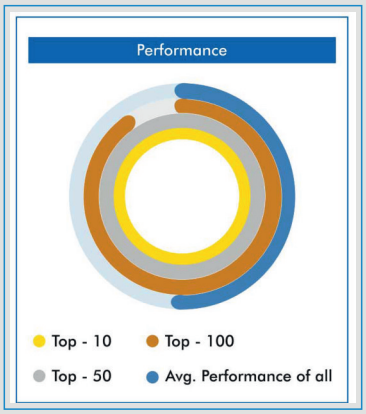


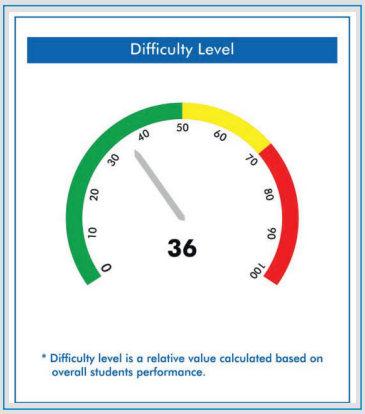




QUESTION WISE STATISTICS:







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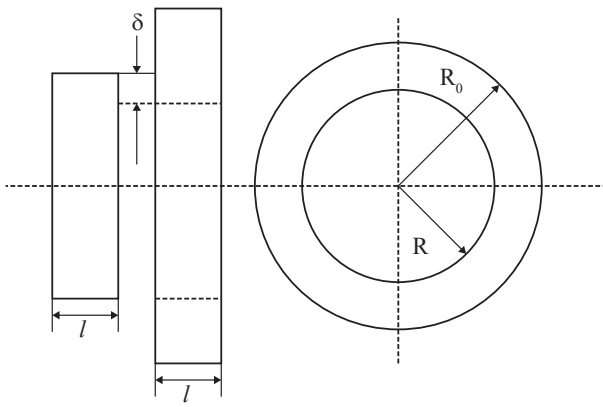
24. Two cylindrical parts of equal length *l*, as shown in the figure, made of steel having Young's modulus E = 200 GPa and Poisson's ratio v = 0.33 are press fitted upon one another. If radial interference δ=0.05 mm, and radii R = 25 mm and R_o = 40 mm, then the contact pressure P in MPa at the interface upon press fit is



(a) 10.7 (b) 1005.3
(c) 60.9 (d) 121.9

24. Ans: (d)

Sol: Given,

E = 200 GPa, μ = 0.33
Radial interference δ = 0.05 mm
Internal radius R = 25 mm
External radius R_o = 40 mm
Considering the shaft to be solid

$$\text{Interface pressure } P = \frac{E\delta}{2R}\left[1-\frac{R^2}{R_o^2}\right]$$

$$= \frac{200\times10^3\times0.05}{2\times25}\left[1-\left(\frac{25}{40}\right)^2\right]$$

$$P = 121.875 \text{ MPa}$$

25. A given steel has identical yield strength of 700 MPa in uni-axial tension and uni-axial compression. If the steel is subjected to pure shear stress such that the three principal stresses are $\sigma_1 = \sigma$, $\sigma_2 = 0$, $\sigma_3 = -\sigma$ with $\sigma_1 \geq \sigma_2 \geq \sigma_3$, then the stress σ in MPa for the initiation of plastic yielding in the steel as per von Mises yield criterion is_____ [*round off to 2 decimal places*]

25. Ans: (404.15)

Sol: Given data

(i) $\sigma_1 = \sigma$; $\sigma_2 = 0$ and $\sigma_3 = -\sigma$
s_{yt} = 700 MPa

(ii) Von-mises stress,

$$\sigma_{vm} = \left\{\frac{1}{2}\times\left\{(\sigma_1-\sigma_2)^2+(\sigma_1-\sigma_3)^2+(\sigma_2-\sigma_3^2)\right\}\right\}^{\frac{1}{2}}$$

$$\therefore \sigma_{vm} = \left\{\frac{1}{2}\times\left\{(\sigma-0)^2+(\sigma-(-\sigma))^2+(0-(-\sigma)^2)\right\}\right\}^{\frac{1}{2}}$$

$$\therefore \sigma_{vm} = \sqrt{3}\times\sigma$$

(iii) As per von-mises criterion for yielding,

$\sigma_{vm} \geq s_{yt}$
$\therefore \sigma_{vm} = s_{yt}$
$\therefore \sqrt{3}\times6 = 700$
$\therefore \sigma = 404.145$ MPa

26. The probability mass function P(x) of a discrete random variable X is given by $P(x) = \frac{1}{2^x}$, where x = 1, 2, ..., ∞. The expected value of X is_____ [*in integer*]

26. Ans: (2)

Sol: $P(x) = \frac{1}{2^x}$

$$E(x) = \sum_{i=1}^{\infty} x_1.p(x_i)$$

$$= \sum_{i=1}^{\infty} x\left(\frac{1}{2^x}\right) = \sum_{i=1} x\left(\frac{1}{2}\right)^{x-1}\left(\frac{1}{2}\right)$$

$$= \frac{1}{2}\sum_{i=1}^{\infty} x\left(\frac{1}{2}\right)^{x-1}$$

$$\therefore \sum_{x=1}^{\infty} x a^{x-1} = \frac{1}{(1-a)^2}$$

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

$$= \frac{1}{2}\left[\frac{4}{1}\right]$$

$$E(x) = 2$$

27. Values of function y(x) at discrete values of x for $0 \le x \le 10$ are given in table.

x	0	1	2	3	4	5	6	7	8	9	10
y(x)	5	3	0	-5	-10	-6	0	5	11	18	30

Using trapezoidal rule, $\int_0^{10} y(x)dx =$

[*round off to one decimal place*]

27. Ans: (33.5)

Sol: Given that

$$h = \frac{b-a}{h} = \frac{10-0}{10} = 1$$

$$\int_a^b y(x)dx = \frac{h}{2}\left[(y_0 + y_n)\right] + \left(y_1 + y_2 + y_3 + \ldots + y_{n-1}\right)$$

$$= \frac{1}{2}\left[(5+30) + 2[3+0-5-10-6+0+5+11+18]\right]$$

$$= \frac{1}{2}\left[35 + 2[16]\right] = \frac{35+32}{2} = 33.5$$

28. Which one of the following is NOT a measure of forecast error?
(a) Mean absolute deviation (MAD)
(b) Mean absolute percent error (MAPE)
(c) Mean sum product error (MSPE)
(d) Mean squared error (MSE)

28. Ans: (c)

29. The time to pass through a security screening at an airport follows an exponential distribution. The mean time to pass through the security screening is 15 minutes. To catch the flight, a passenger must clear the security screening within 15 minutes. The probability that the passenger will miss the flight is____ [*round off to 3 decimal places*]

29. Ans: (0.37)

30. A product has an exponential time-to-failure distribution with a constant failure rate of 0.00006 per hour. The reliability of the product after 4000 hours of operation is
(a) 0.7866 (b) 0.6866
(c) 0.8866 (d) 0.5866

30. Ans: (a)

Sol: $R(t) = e^{-\lambda t}$

$= e^{-0.00006 \times 4000}$

$= 0.7866$

31. Which one among the following mechanisms is NOT used for transforming rotation to translation in machine tools?
(a) Screw-nut system
(b) 4-bevel gear type differential mechanism
(c) Whitworth mechanism
(d) Cam and cam follower system

31. Ans: (b)

Sol: Differential mechanisms consisting of bevel gears. These mechanisms are widely used in automobiles to provide different rotational speeds to the wheels powered by a single source. This is essential for the functioning of an automobile because, while tackling a turn, the outer wheel of the automobile must rotate faster than the inner wheel. This mechanism is also widely used in machine tools on account of its compactness.

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Batch Type	Timings	Batch Date	Duration	Venue
Morning, Evening Batches	**6am to 8am & 6pm to 8:30pm**	20th March 2021	8 to 10 Months	Abids, Dilsukhnagar, Kukatpally.

GATE + PSUs – 2022 & ESE + GATE + PSUs – 2022 — @ DELHI

Regular Batches	Daily 5 to 6 Hours	5th March 2021	6 to 7 Months	ACE campus Saket
		7th April 2021		
		15th May 2021		
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Regular / Weekend Batches	Daily 5 to 6 Hours	20th March 2021	6 to 7 Months	Pune Classroom

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32. The eigenvalues of matrix $A = \begin{bmatrix} 8 & 3 \\ 2 & 7 \end{bmatrix}$ are 5 and 10. For matrix $B = A + \alpha I$, where α is a constant and I is 2×2 identify matrix, its eigenvalues are

(a) 5, 10 (b) $5 - \alpha$, $10 - \alpha$

(c) 5α, 10α (d) $5 + \alpha$, $10 + \alpha$

32. Ans: (d)

Sol: $A = \begin{bmatrix} 8 & 3 \\ 2 & 7 \end{bmatrix}$

Eigen value = 5, 10

$B = A + \alpha I = \lambda + \alpha(1)$

when $\lambda = 5$

$\Rightarrow 5 + \alpha(1) = 5 + \alpha.$

when $\lambda = 10$

$\Rightarrow 10 + \alpha(1) = 10 + \alpha.$

33. There are a number of identical components in a parallel system. When the system reliability is 0.97 and the reliability of each individual component is 0.68, the number of identical components in the system is (if actual value is a fraction, it may be rounded up to the next higher integer).

(a) 6 (b) 4

(c) 8 (d) 2

33. Ans: (b)

Sol: $R_{parallel} = 1 - (1 - R_c)^n$

$R_{Parallel} = 0.97$

$R_c = 0.68$

$0.97 = 1 - (1-0.68)^n$

$\Rightarrow 0.03 = (0.32)^n$

$\ln(0.03) = n \ln(0.32)$

$n = \dfrac{\ln(0.03)}{\ln(0.32)} = 3.07 \simeq 4$

34. A 150 mm wide polyamide flat belt is transmitting 15 kW power through a belt-pulley system. The driving pulley of 150 mm pitch diameter is rotating at 200 RPM. If F_1 is the belt tension on high tension side, and F_2 is the belt tension on low tension side, then the difference in belt tensions $\Delta F = F_1 - F_2$ in N is _____. (round off to one decimal place)

34. Ans: (9549.3)

Sol: (i) P = 15 kW,

d = 150 mm = 0.15 m

N = 200 rpm

(ii) For belt drive,

$P = \dfrac{2\pi N}{60} \times \{F_1 - F_2\} \times \dfrac{d}{2}$

$\therefore 15 \times 10^3 = \dfrac{2\pi \times 200}{60} \times \Delta F \times \dfrac{0.15}{2}$

$\therefore \Delta F = 9549.3$ N

35. 'GO' and 'NO GO' snap gauges are to be designed for a shaft $36.000^{+0.070}_{+0.010}$ mm. Gauge tolerance can be taken as 5% of the hole tolerance. Following the ISO system of gauge design, the respective sizes of 'GO' and 'NO GO' gauges are

(a) 36.018 mm and 36.062 mm

(b) 36.013 mm and 36.067 mm

(c) 36.020 mm and 36.060 mm

(d) 36.015 mm and 36.065 mm

35. Ans: (b)

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36. Match the component with the corresponding manufacturing process in the table below.

	Component		Manufacturing process
P	Aluminum alloy piston for IC engine	1	Blow molding
Q	Low carbon steel oil pan	2	Powder metallurgy
R	Tungsten carbide cutting tool insert	3	Sand casting
S	Plastic bottle	4	Deep drawing

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

36. Ans: (c)

Sol: In permanent-mold casting (also called hard-mold casting), two halves of a mold are made from materials with high resistance to erosion and thermal fatigue, such as cast iron, steel, bronze, graphite, or refractory metal alloys. Typical parts made are automobile pistons, cylinder heads, connecting rods, gear blanks for appliances, and kitchenware. Deep drawing is used make low carbon oil pans.

Powder metallurgy is used for manufacturing products or articles from powdered metals by placing these powders in molds and are compacting the same using heavy compressive force. Typical examples of such article or products are grinding wheels, filament wire, magnets, welding rods, tungsten carbide cutting tools, self-lubricating bearings electrical contacts and turbines blades having high temperature strength.

Blow molding (or moulding) is a manufacturing process for forming and joining together hollow plastic parts. It is also used for forming glass bottles or other hollow shapes.

37. Heat is being removed from a refrigerator at a rate of 300 kJ/min to maintain its inside temperature at 2°C. If the input power to the refrigerator is 2 kW, the coefficient of performance of the refrigerator is _____[round off to one decimal place]

37. Ans: (2.5)

Sol: NRE = $\dot{Q} = \frac{300}{60} = 5$ kW

W = 2 kw

$COP = \frac{\dot{Q}}{W} = \frac{5}{2} = 2.5$

38. Pearlite microstructure in an eutectoid steel consists of alternating layers of two phases, namely α ferrite and

(a) Cementite (b) Martensite
(c) Austenite (d) Bainite

38. Ans: (a)

Sol: Pearlite is a two-phased, lamellar (or layered) structure composed of alternating layers of ferrite (87.5 wt%) and cementite (12.5 wt%) that occurs in some steels and cast irons.

39. A fluid with dynamic viscosity μ = 1 Pa.s is flowing through a circular pipe with diameter 1 cm. If the flow rate (discharge) in the pipe is 0.2 liter/s, the maximum velocity in m/s of the fluid in the pipe is (assume fully developed flow and take fluid density ρ = 1000 kg/m^3) ____ [round off to one decimal place]

39. Ans: (5.1)

Sol: Given,

μ = 1 Pa. sec, d = 0.01 m
Q = 0.0002 m^3/sec, ρ = 1000 kg/m^3
V_{max} = ?
Q = AV
$Q = \frac{\pi}{4}d^2.V$

$V = 4Q/\pi d^2$

Reynolds number $(Re) = \frac{\rho.V.d}{\mu}$

$= \frac{\rho.4Q \times d}{\pi d^2 \times \mu}$

$= \frac{4.\rho Q}{\pi.d.\mu}$

$= \frac{4 \times 1000 \times 0.0002}{\pi \times 0.01 \times 1}$

$= 25.46 < 2000$

Flow through the pipe is Laminar

$Q = A\overline{V} = A.\frac{V_{max}}{2} \quad \left[V_{max} = 2\overline{V}\right]$

$\therefore \overline{V} = \frac{V_{max}}{2}$

$0.0002 = \frac{\pi}{4}(0.01)^2 \times \frac{V_{max}}{2}$

$\therefore V_{max} = 5.093$ m/s

40. In the classical economic order quantity (EOQ) model, let Q and C denote the optimal order quantity and the corresponding minimum total annual cost (the sum of the inventory holding and ordering costs). If the order quantity is estimated incorrectly as Q′ = 2Q, then the corresponding total annual cost C′ is

(a) C′ = 1.25C (b) C′ = 1.75C

(c) C′ = 1.5C (d) C′ =2C

40. Ans: (a)

Sol: Economic Order Quantity, EOQ = Q

optimal cost = C

$(TVC)_{EOQ} = \sqrt{2ACSI}$

Ordering cost (OC) $= \frac{A}{Q}S$

Inventory carrying cost (ICC) $= \frac{Q}{2}CI$

At EOQ, OC = ICC

At EOQ = C = 2OC = 2ICC

Quantity = Q' = 2Q

$OC = \frac{A}{2Q}S$

$ICC = \frac{2Q}{2}CI$

$C' = \frac{1}{2}OC + 2 \times ICC$

C' = 2.5 OC = 2.5 ICC

$\frac{C'}{C} = \frac{2.5\,OC}{2\,OC} = \frac{2.5\,ICC}{2\,ICC} = 1.25$

C'=1.25C

41. A M30 bolt needs to be subjected to pretension F_i = 350 kN. If the torque coefficient K of the bolt is 0.2, then the torque in Nm needed to achieve this pretension is _____ [in integer]

41. Ans: (2100)

Sol: Given data:

i) M30 bolt ∴ d = 30 mm

ii) Initial tightening Load, F_i = 350 kN

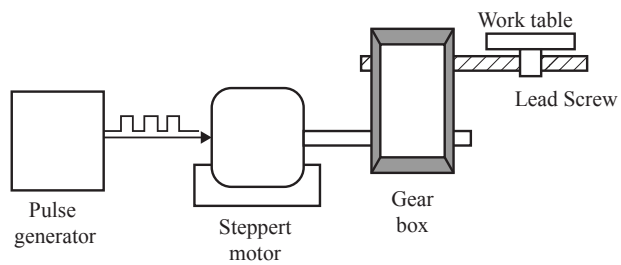
iii) Torque coefficient, K = 0.2

Torque required for pretension = $K \times F_i \times d$

$= 0.2 \times 350 \times 10^3 \times 30 \times 10^{-3}$

= 2100 Nm

42. In a point-to-point open-loop NC drive, a stepper motor with 1.8° step angle is coupled to a leadscrew through a gear reduction of 4:1 (4 rotations of the motor enables 1 rotation of leadscrew). The single-start leadscrew has a pitch of 4 mm. The worktable of the system is driven by the leadscrew. If the table moves at a uniform speed of 10 mm/s, the pulse frequency (in Hz) required to drive the stepper motor is _____[round off to one decimal place]



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42. Ans: (2000)

Sol: Given, Step angle = 1.8°

Gear reduction = 4:1

Pitch, P = 4 mm

Table speed = 10 mm/s

$\therefore$ Pulse frequency (Hz) = ?

$\therefore \dfrac{\text{Total number of steps}}{\text{rotation}} = \dfrac{360°}{1.8°}$

$\dfrac{\text{Steps}}{\text{rotation}} = \dfrac{200 \text{ steps}}{\text{rotation}}$

$\therefore$ 200 Pulses required for 1 rotation of motor

Pulses	Distance (work table)
200	1/4×4 = 1 mm
Pulses	10 mm

$\therefore$ Pulses = 200 × 10 = 2000 Pulses

$\therefore$ Frequency = 2000 Hz

43. Which one of the following defects is NOT associated with welding processes?

(a) Hydrogen embrittlement (b) Angular distortion

(c) Earring (d) Hot tear

43. Ans: (c)

Sol: Earing is one of the major defects observed during deep drawing process due to anisotropic nature of sheet metal.

44. Match the measuring feature with the corresponding measuring instrument in the table below.

	Measuring feature		Measuring instrument
P	Flatness error of a surface plate	1	Auto collimator
Q	Profile of a cam	2	Tool maker's microscope
R	Alignment error of a machine tool slide way	3	Dividing head and dial gauge
S	Pitch and angle errors of screw thread	4	Optical interferometer

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

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

44. Ans: (a)

Sol: The NPL flatness interferometer is used for checking flatness between gauge surfaces.

Tool maker's microscope is a multifunctional device that is primarily used for measurement in factory shop floors. Designed with the measurement of workpiece contours and inspection of surface features in mind, a tool maker's microscope supports a wide range of applications from shop floor inspection, and measurement of tools and machined parts, to precision measurement of test tools in a measuring room.

An autocollimator is used for the measurement of straightness and flatness of machine parts and accessories such as guideways, machine tables, and surface plates, among others.

45. The top layer of a flat 750 mm × 300 mm rectangular mild steel plate is to be machined with a single depth of cut using a shaping machine. The plate has been fixed by keeping 750 mm side along the tool travel direction. If the approach and the over-travel are 25 mm each, average cutting speed is 10 m/min, feed rate is 0.4 mm/stroke, and the ratio of return time to cutting time of the tool is 1:2, the time (in minutes) required to complete the machining operation is _____ [round off to one decimal place]

45. Ans: (90)

Sol: $M = \dfrac{1}{QRR} = \dfrac{1}{2} = 0.5$

$$\text{Total m/c time} = \frac{W}{f}\left(\frac{L}{V_c}\right)(1+M)$$

$$= \frac{300}{0.4} \times \frac{800}{10000}(1+0.5) = 90 \text{ min}$$

$\therefore L = l_a + l + l_0$

L = 25 + 750 + 25 = 800 mm

V_c = 10 m/min = 10000 mm/min

F = 0.4 mm/stroke

Total machining time = 90 min

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46. A 3.5 mm thick sheet is rolled using a two high rolling mill to reduce the thickness under plane strain condition. Both rolls have a diameter of 500 mm and are rotating at 200 RPM. The coefficient of friction at the sheet and roll interface is 0.08, and the elastic deflection of the rolls is negligible. If the mean flow strength of the sheet material is 400 MPa, then the minimum possible thickness (in mm) of sheet that can be produced in a single pass is _____[round off to 2 decimal places]

46. Ans: (1.9)

Sol: Given, $H_0 = 3.5$ mm, $D = 500$ mm

$N = 200$ rpm, $\mu = 0.08$

$H_{1(min)} = ?$, $\bar{Y}_f = 400$ MPa

$H_{1(min)} = H_0 - (\Delta H)_{max}$

$= H_0 - \mu^2 R$

$= 3.5 - 0.08^2 \times 250$

$= 3.5 - 1.6$

$= 1.9$ mm

47. In a turning operation, doubling the cutting speed (V) reduces the tool life (T) to $\frac{1}{8}$th of the original tool life. The exponent n in the Taylor's tool life equation, $VT^n = C$ is

(a) $\frac{1}{3}$ (b) $\frac{1}{8}$ (c) $\frac{1}{2}$ (d) $\frac{1}{4}$

47. Ans: (a)

Sol: $VT^n = C$ ..... (i)

$$2V\left(\frac{1}{8}T\right)^n = C \text{ ..... (ii)}$$

$$\left(\frac{1}{8}\right)^n = \frac{1}{2}$$

$$n\ell n\left(\frac{1}{8}\right) = \ell n\left(\frac{1}{2}\right)$$

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

48. A tool of an NC machine has to move along a circular arc from (20,20) to (10,10), while performing an operation. The center of the arc is at (20,10). Which one of the following NC tool commands performs the above mentioned operation?

(a) N020 G03 X20 Y20 X10 Y10 R10

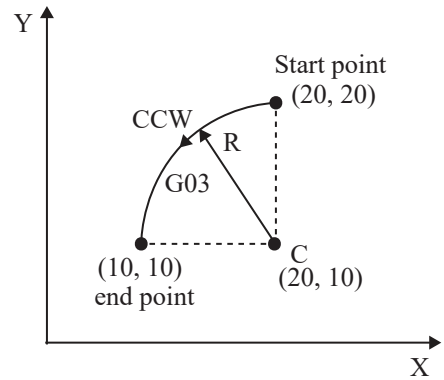
(b) N020 G01 X20 Y20 X10 Y10 R10

(c) N020 G02 X20 Y20 X10 Y10 R10

(d) N020 G02 X10 Y10 X20 Y20 R10

48. Ans: (a)

Sol:



$R = 10$

$\therefore$ NO20 G03 X20 Y20 X10 Y10 R10

49. The initial cost of a machine is INR 10,00,000 and its salvage value after 10 years of use is INR 50,000. Using the straight line depreciation method, the book value in INR of the machine at the end of 7th year is _____ [in integer]

49. Ans: (3,35,000)

Sol: Straight line Method

Depreciation $\frac{\text{Cost} - \text{Salvage value}}{\text{Life time}}$

Cost = 10 Lakh, Salvage value = 50,000.

Life time = 10 years.

Depreciation $= \frac{10^6 - 50,000}{10} = 95000$

All the end of 7th year, the total depreciated value $= 95000 \times 7 = 665000$.

So, book value at the end of 7th year

$= 10,00,000 - 6,65,000 =$ Rs 3,35,000

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50. When acceptance number of a single sampling plan under attribute category is zero with sample size less than or equal to 10, the Operating Characteristic (OC)curve is
(a) A vertical line
(b) A horizontal line
(c) A convex function
(d) An inverted S-shaped curve

50. Ans: (a)

51. A wire of 5 mm diameter is drawn into a wire of 4 mm diameter through a conical die at a constant pulling speed of 5 m/s. Neglecting the coefficient of friction and redundant work, the drawing stress (σ_d) in MPa for the above process is given by $\sigma_d = \bar{\sigma}\,\ell n\left[\frac{1}{1-r}\right]$, where $\bar{\sigma}$ is the mean flow strength of wire material in MPa, and r is the ratio of decrease in area of cross-section to initial area of cross-section of the wire. If the mean flow strength of wire material is 600 MPa, then the power required in kW in the above wire drawing process is _____ [round off to 2 decimal places]

51. Ans: (16.82)

Sol: Given, $d_0 = 5$ mm, $d_1 = 4$ mm

$$\therefore r = \frac{A_0 - A_1}{A_0} = 1 - \frac{A_1}{A_0}$$

$$r = 1 - \frac{\frac{\pi}{4}(4)^2}{\frac{\pi}{4}(5)^2}$$

$$r = 1 - \left(\frac{4^2}{5^2}\right)$$

$$r = 0.36$$

$$\sigma_d = \bar{\sigma} \times \ell n\left(\frac{1}{1-r}\right)$$

$$\sigma_d = 600 \times \ell n\left(\frac{1}{1-0.36}\right)$$

$$\sigma_d = 267.77 \text{ MPa}$$

$\therefore$ drawing load $= \sigma_d \times A_f$

$$= 267.77 \times \frac{\pi}{4} \times 4^2 = 3364.92 \text{ N}$$

$\therefore$ Drawing power = 3364.92 × 5 m/sec
= 16.82 kW

52. A cylindrical mild steel tensile test specimen of gauge length 50 mm and diameter 10 mm is extended in two stages at a deformation speed of 4 mm/min. The specimen is extended from 50 mm to 55 mm in the first stage, and from 55 mm to 60 mm in the second stage. Neglecting elastic deformation, the total longitudinal true strain is _____ [round off to 2 decimal places]

52. Ans: (0.182)

Sol: Given, $L_0 = 50$ mm, $d_0 = 10$ mm
$L_1 = 55$ mm, $L_2 = 60$ mm

$$\therefore \varepsilon_{True} = \ell n\left(\frac{L_2}{L_0}\right)$$

$$\varepsilon_{True} = \ell n\left(\frac{60}{50}\right)$$

Total longitudinal true strain, $\varepsilon = 0.182$

53. A time study is carried out for a spot welding operation which is being performed by an operator. The time taken (in seconds) for five observations are recorded as 40, 35, 45, 37 and 43, respectively. If the standard time and the allowance for this operation are 45 seconds and 9 seconds respectively, then the performance rating (in percentage) of the operator is _____[in integer]

53. Ans: (90)

Sol: Standard time
= Mean observed time × Rating factor + Allowance
Standard Time = 45 sec.
Allowance = 9 sec.

Mean observed Time

$$= \frac{40 + 35 + 45 + 37 + 43}{5} = 40 \text{ sec.}$$

$\Rightarrow 45 = 40 \times$ Rating Factor + 9
Rating Factor = 90%.

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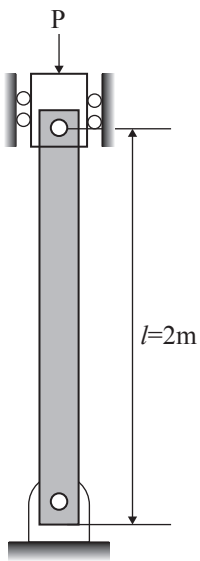
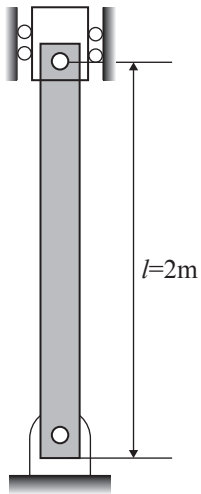
54. A circular rod of length l = 2 m is subjected to a compressive load P, as shown in the figure. The bending (flexural) rigidity of the rod is 2000 Nm^2. If both ends are pinned, then the critical load P_{cr} in N (rounded to the nearest integer) at which the rod buckles elastically is



(a) 1238 (b) 2000 (c) 5167 (d) 4935

54. Ans: (d)

Sol:



$(L_e)_{HINGE, HINGE} = L = 2\ M$

$EI = 2000\ N\text{-}m^2$

$$P_e = \frac{\pi^2 EI_{min}}{L_e^2}$$

$$P_e = \frac{\pi^2 \times 2000}{2^2}$$

$P = 4934.80\ N \simeq 4935\ N$

$p = 4935\ N$

55. Which one of the following is an improvement type heuristic algorithm for computerized layout design technique?

(a) Computerized relationship layout planning (CORELAP)

(b) Computerized relative allocation of facilities technique (CRAFT)

(c) Systematic layout planning (SLP)

(d) Plant layout analysis and evaluation technique (PLANET)

55. Ans: (b)

Sol: CRAFT is the improvement algorithm which is used in plant layout.

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