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GATE 2021

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Questions & Solutions

Exam held on 07/02/2021
Afternoon Session

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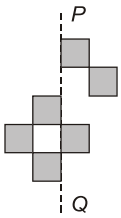
SECTION-A GENERAL APTITUDE

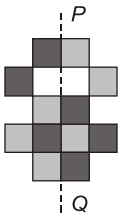
Q.1



The least number of squares that must be added so that the line *P*-*Q* becomes the line of symmetry is _____.

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

Ans. (d)



To make *P*-*Q* as symmetric line, minimum number of ■ square added = 6.

End of Solution

Q.2 *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) 9 (b) 7
(c) 3 (d) 11

Ans. (b)

Given, $\frac{p}{q}+\frac{q}{p}=3$

Squaring both sides,

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

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

$$\Rightarrow \frac{p^2}{q^2}+\frac{q^2}{p^2}=9-2=7$$

End of Solution

Q.3 Nostalgia is to anticipation as _____ is to _____.

Which one of the following options maintains a similar logical relation in the above sentence?

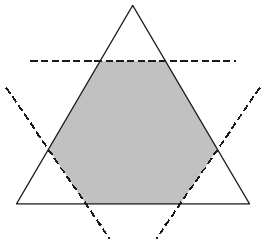
(a) Past, future
(b) Present, past
(c) Future, present
(d) Future, past

Ans. (a)

Nostalgia refers to a feeling, fondness and slight sadness thinking of past and anticipate is to predicting future.

End of Solution

Q.4

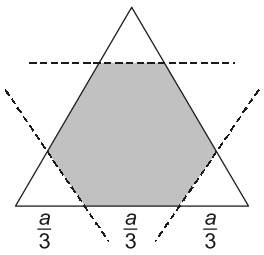


Corners are cut from an equilateral triangle to produce a regular convex hexagon as shown in the figure above.

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

(a) 3 : 4
(b) 4 : 5
(c) 2 : 3
(d) 5 : 6

Ans. (c)



Let the side of the two larger equilateral triangle = a

Then side of regular hexagon = $\left(\frac{a}{3}\right)$

Area of regular Hexagon = $6\times\frac{\sqrt{3}}{4}\left(\frac{a}{3}\right)^2$

Area of triangle = $\frac{\sqrt{3}}{4}(a)^2$

Required ratio = $\frac{6\sqrt{3}}{4}\times\frac{a^2}{9}:\frac{\sqrt{3}}{4}a^2$

$6 : 9 = 2 : 3$

End of Solution

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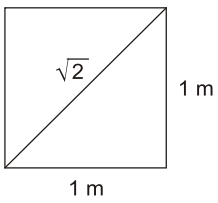
Q.5 Consider a square sheet of side 1 unit. In the first step, it is cut along the main diagonal to get two triangles. In the next step, one of the cut triangles is revolved about its short edge to form a solid cone. The volume of the resulting cone, in cubic units, is _____.

(a) $\frac{3\pi}{2}$ (b) 3π

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

Ans. (c)



One of the triangle is revolved about its short side, resulting a cone

Hence, $r = 1, \quad H = 1$

Volume of cone, $V = \frac{1}{3}\pi r^2 H = \frac{\pi}{3}(1)^2(1)$

$V = \frac{\pi}{3}$

End of Solution

Q.6 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), (iii) and (iv) (b) (i) and (iii)

(c) (ii) and (iii) (d) (ii) and (iv)

Ans. (b)

Ubiquitous is the keyword to justify option (i). Positive and negative effect for humans justifies option (iii).

End of Solution

Q.7 Given below are two statements and two conclusions.

Statement 1 : All purple are green.

Statement 1 : 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) Only conclusion II is correct.

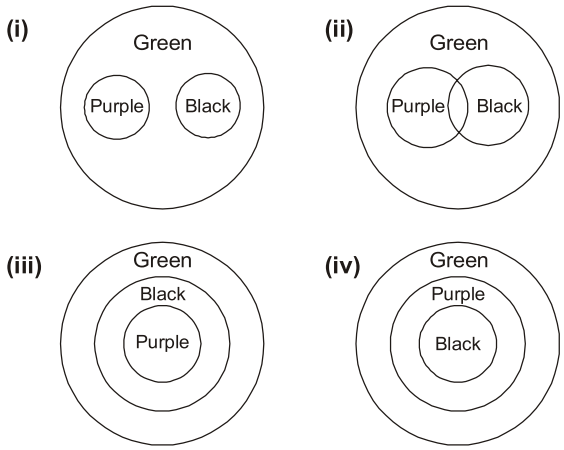
(b) Only conclusion I is correct.

(c) Either conclusion I or II is correct.

(d) Both conclusion I and II are correct.

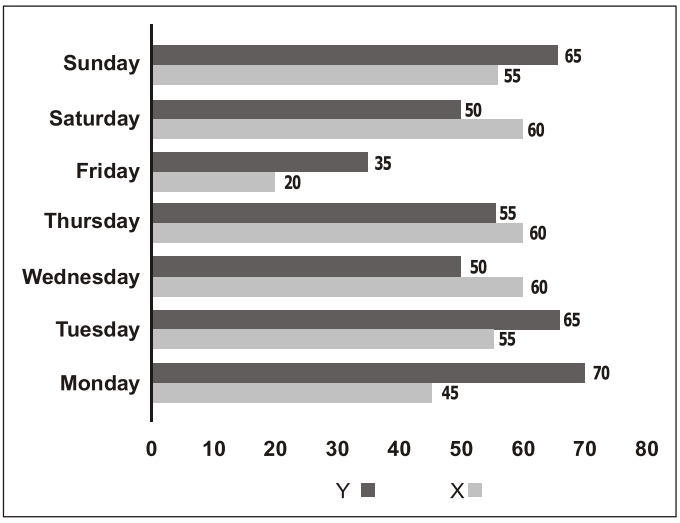
Ans. (c)

Possible cases can be,



End of Solution

Q.8



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) 7 (b) 6

(c) 5 (d) 4

Ans. (b)

$$\text{On Sunday, the percentage} = \frac{65-55}{55}\times 100 = 18.18\%$$

$$\text{On Saturday, the percentage} = \frac{60-50}{50}\times 100 = 20\%$$

$$\text{On Friday, the percentage} = \frac{35-20}{20}\times 100 = 75\%$$

$$\text{On Thursday, the percentage} = \frac{60-55}{55}\times 100 = 9.09\%$$

$$\text{On Wednesday, the percentage} = \frac{60-50}{50}\times 100 = 20\%$$

$$\text{On Tuesday, the percentage} = \frac{65-55}{55}\times 100 = 18.18\%$$

$$\text{On Monday, the percentage} = \frac{70-45}{45}\times 100 = 55.56\%$$

Total six days are there when one of the students spent a minimum of 10% more than the other student.

End of Solution

Q.9 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) 9,95,006 (b) 10,00,000

(c) 12,51,506 (d) 9,92,500

Ans. (b)

$$1102500 = x\left(1+\frac{5}{100}\right)^2$$

$$1102500 = x\left(\frac{21}{20}\right)^2$$

$$x = 10,00,000$$

End of Solution

Q.10 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) (i) and (iii)
(b) (i) and (ii)
(c) (i) and (iv)
(d) (ii) and (iii)

Ans. (a)

Wake - Woke - Woken are three form of the verb.

Hence, option (i) and (iii) are correct.

End of Solution

■■■■

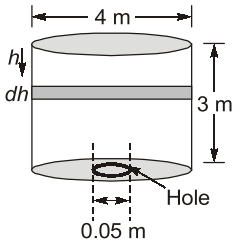
SECTION-B TECHNICAL

Q.1 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) 3154

(c) 1807 (d) 5005

Ans. (d)



Given: Diameter of tank, $D = 4$ m,
Diameter of hole, $d = 5$ cm $= 0.05$ m
Height of the tank, $H = 3$ m

$$-A\frac{dh}{dt} = a\sqrt{2gh}$$

$$\Rightarrow \quad -\frac{A}{a}\frac{dh}{\sqrt{h}} = \sqrt{2g}dt$$

Integrating both sides,

$$-\frac{A}{a}\int_H^0 \frac{dh}{\sqrt{h}} = \sqrt{2g}\int_0^t dt$$

$$-\frac{A\times 2}{a}\left(h^{1/2}\right)_H^0 = \sqrt{2g}\,t$$

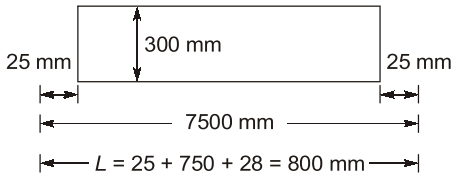
$$\Rightarrow \quad 2H^{1/2}\frac{A}{a} = \sqrt{2g}\,t$$

$$t = \sqrt{\frac{2H}{g}}\times\frac{A}{a} = \sqrt{\frac{2\times 3}{9.81}}\times\left(\frac{4}{0.05}\right)^2 = 5005.196\ s$$

End of Solution

Q.2 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 min, feed rare is 0.4 mm/stroke, and the ratio of return time to cutting rime of the tool is 1 : 2. The time (in minutes) required to complete the machining operation is_____. [round off To one decimal place]

Ans. (90) (89 to 91)



Given: $V_R = 2\ V_C$
Time required for one pass,

$$t = \frac{L}{V_C} + \frac{L}{V_R}$$

$$t = \frac{0.8}{10} + \frac{0.8}{10 \times 2} = 0.12 \text{ min}$$

$$N = \frac{W}{f} = \frac{300}{0.4} = 750 \text{ passes}$$

Time required for total machining,

$$T = tN = 0.12 \times 750 = 90 \text{ min}$$

End of Solution

Q.3 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]

Ans. 90 (90 to 90)

$$OT = 40 \text{ min}, \quad NT = OT \times RF$$

$$ST = NT + \text{Allow}$$

$$45 = 40 \times \text{RF} + 9$$

$$dRF = 0.9 \rightarrow 90\%$$

End of Solution

Q.4 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

Ans. 4 (4 to 4)

By EDD

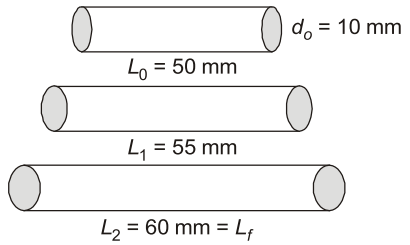
Jobs	P.T	D.D	Job Flow Time	Tardiness
B	5	10	0 + 5 = 5	0
C	7	12	5 + 7 = 12	0
A	8	14	12 + 8 = 20	6
D	9	19	20 + 9 = 29	10

$$\text{Avg Tardiness} = \frac{16}{4} = 4 \text{ days}$$

End of Solution

Q.5 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]

Ans. (0.18) (0.17 to 0.19)



$$\epsilon_T = \ln\left(\frac{L_f}{L_o}\right) = \ln\left(\frac{60}{50}\right) = 0.18232 \simeq 0.18$$
$$= 0.18$$

End of Solution

Q.6 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 a in MPa for the initiation of plastic yielding in the steel as per von Mises yield criterion is_____. [round off to 2 decimal places]

Ans. 404.14 (404.10 to 404.20)

$\sigma_y = 700$, $\sigma_1 = \sigma$, $\sigma_2 = 0$, $\sigma_3 = -6$

$$u_s = \frac{\sigma_y^2}{\sigma G}$$

$$\frac{1}{12G}\left[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2\right] = \frac{\sigma_y^2}{6G}$$

$$\frac{1}{2}\left[\sigma^2 + \sigma^2 + 4\sigma^2\right] = \sigma_y^2$$

$$3\sigma^2 = \sigma_y^2$$

$$\sigma = \frac{\sigma_y}{\sqrt{3}} = \frac{700}{\sqrt{3}} = 404.14 \text{ MPa}$$

End of Solution

Q.7 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]

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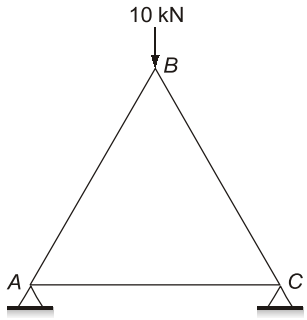
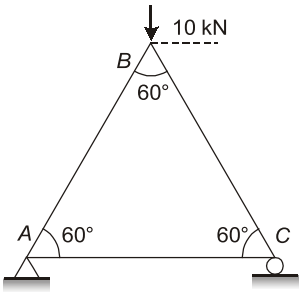
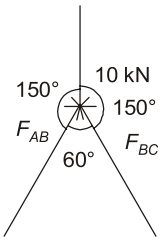


Ans. –5773.5 (–5773.7 to –5773.4)



Joint *B*



$$\frac{F_{BC}}{\sin 150} = \frac{10}{\sin 60} = \frac{F_{AB}}{\sin 150} \text{ (Lami's Theorem)}$$

$$F_{BC} = \frac{10 \times \sin 150^\circ}{\sin 60^\circ} = 5.7735 \text{ kN (C)} = -5773.5 \text{ N}$$

End of Solution

Q.8 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 liters/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]

Ans. 5.095 (5.0 to 5.2)

$$\text{Re} = \frac{VD\rho}{\mu} = \frac{4Q\rho}{\pi \times \mu D} = \frac{4 \times 0.2 \times 10^{-3} \times 1000}{\pi \times 1 \times 0.01}$$

$$= 25.477 \text{ (Laminar flow)}$$

$\because$ Re < 2000

$$(V_{max})_{centerline} = 2\ V_{avg} = 2\times\frac{Q}{\frac{\pi}{4}\times D^2} = \frac{2\times 0.2\times 10^{-3}}{\frac{\pi}{4}\times(0.01)^2} = 5.095\ \text{m/sec}$$

End of Solution

Q.9 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 D (b) Site B

(c) Site C (d) Site A

Ans. (c)

Cumulative score = $\Sigma(Wt \times \text{Score})$

A	B	C	D
50	45	57	46

End of Solution

Q.10 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 arc power, then the required welding speed in mm/s is_____. [round off to one decimal place]

Ans. (9) (8.8 to 9.2)

$V_0 = 60$ V
$I_s = 600$ A
$H_m = 10$ J/mm^3
$\eta_n = 80\%$
$\eta_m = 25\%$
$A = 20$ mm^2
$v = ?$

$$\frac{V_t}{V_0} + \frac{I_t}{I_s} = 1$$

$$V_t = V_0 - \left(\frac{I_t}{I_s}\right)V_0 = 60 - \left(\frac{I_t}{600}\right)60$$

$$P = V_t I_t = \left[60 - \left(\frac{I_t}{600}\right)60\right] I_t$$

For max Power, $\frac{\partial P}{\partial I_t} = 0 \Rightarrow I_t = 300\ \text{A}$

$V_t = 30\ \text{V}$

$$\left[\text{Shortcut, } I_t = \frac{I_s}{2} = \frac{600}{2} = 300,\ V_t = \frac{V_0}{2} = \frac{60}{2} = 30\right]$$

$$\eta_m = \frac{H_m}{\frac{V_t I_t}{Av} \times \eta_h} \Rightarrow 0.25 = \frac{10}{\frac{300 \times 30}{20 \times v} \times 0.8}$$

$v = 9$ mm/s

End of Solution

Q.11 The dimensionless number defined by the ratio of inertial force to viscous force is called:

(a) Froude number
(b) Mach number
(c) Weber number
(d) Reynolds number

Ans. (d)

End of Solution

Q.12 Which of the following is NOT a measure of forecast error?

(a) Mean Absolute Deviation (MAD)
(b) Mean Sum Product Error (MSPE)
(c) Mean Square Error (MSE)
(d) Mean Absolute Percent Error (MAPE)

Ans. (b)

End of Solution

Q.13 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	
Manpower	1	1	10
R1	1	2	18
R2	2	1	18

The maximum profit the company can make is

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

Ans. (d)

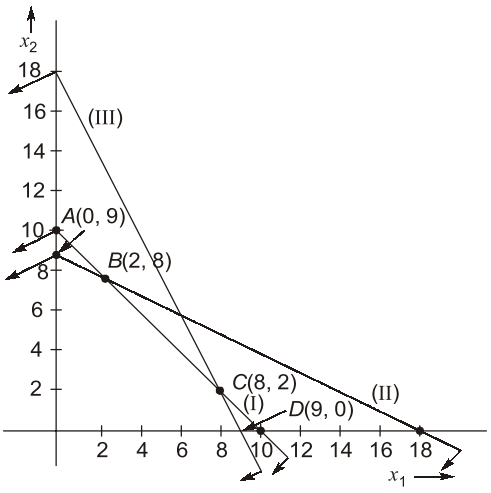
Resource	Resource usage per unit of production		Amount of resource available
	P (x_1)	Q(x_2)	
Manpower	1	1	10
R1	1	2	18
R2	2	1	18

$$\text{Max } Z = 4x_1 + 5x_2$$

$$x_1 + x_2 \le 10 \quad \text{...(i)}$$

$$x_1 + 2x_2 \le 18 \quad \text{...(ii)}$$

$$2x_1 + x_2 \le 18 \quad \text{...(iii)}$$



$Z(A) = 45$
$Z(B) = 48$
$Z(C) = 42$
$Z(D) = 36$

End of Solution

Q.14 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) 0.101 (d) 0.301

Ans. (c)

Since all rules are used simultaneously. Thus,

$$P\left(\frac{\text{Overall}}{\text{Error}}\right) = P\text{ [Error in at least one of them]}$$

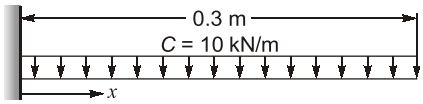
$$= 1 - P\text{[Error in none of them]}$$

$$= 1 - 0.995 \times 0.98 \times 0.97 \times 0.95$$

$$= 0.101$$

End of Solution

Q.15 A cantilever beam of length 0.3 in is subjected to a uniformly distributed load C = 10 kN/n, 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) 1.10 (b) 0.05
(c) 0.09 (d) 0.02

Ans. (c)

$$\frac{1}{R} = \frac{M}{EI} = \frac{10 \times 10 \times 0.3 \times 0.15}{5000}$$
$$= 0.09 \text{ m}^{-1}$$

End of Solution

Q.16 Values of function $y(x)$ at discrete values of x for $0 \le x \le 10$ are given in table. Using trapezoidal rule, $\int_0^{10} y(x)dx =$ _____. [round off to one decimal place]

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

Ans. 33.5 (33.4 to 33.6)

Trapezoidal rule: $y = \int_0^{10} y(x)dx$

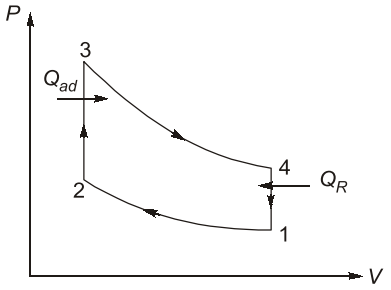
Where, $y = \frac{h}{2}\left[y_0 + y_{10} + 2(y_1 + y_2 + y_3 + ... + y_9)\right]$

$$y = \frac{1}{2}\left[5 + 30 + 2(16)\right] = 33.5$$

End of Solution

Q.17 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]

Ans. 52.4 (52.2 to 52.5)



$$Q_{ad} = Q_{23} = 800 \text{ kJ/kg}$$
$$Q_R = Q_{41} = 381 \text{ kJ/kg}$$
$$\eta = 1 - \frac{Q_R}{Q_{ad}} = 1 - \frac{381}{800} = 52.375\% \approx 52.4\%$$

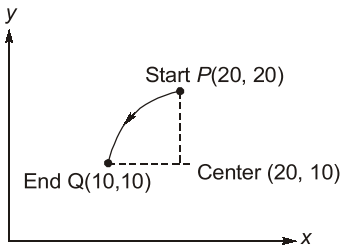
End of Solution

Q.18 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 G02 X20 Y20 X10 Y10 R10 (b) N020 G01 X20 Y20 X10 Y10 R10

(c) N020 G03 X20 Y20 X10 Y10 R10 (d) N020 G02 X10 Y10 X20 Y20 R10

Ans. (c)



It is counter clockwise interpolation (G03).

End of Solution

Q.19 The minimum value of function f defined by
$f(x, y, z) = x^2 + 5y^2 + 5z^2 - 4x + 10y - 40z + 300$
is _____. [in integer]

Ans. (136) (136 to 136)

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

$$\frac{\partial f}{\partial x} = 2x - 4$$

$$\frac{\partial f}{\partial y} = 10y + 40$$

$$\frac{\partial f}{\partial z} = 10z - 40$$

For stationary points,

$$\frac{\partial f}{\partial x} = 0,$$
$$x = 2$$
$$\frac{\partial f}{\partial y} = 0$$

$$y = -4$$

$$\frac{\partial f}{\partial z} = 0$$

$$z = 4$$

$$f(x, y, z) = f(2, -4, 4) = 136$$

End of Solution

Q.20 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) 2 (d) 8

Ans. **(b)**

$$R_s = 1 - [(1 - R_1)(1 - R_2)....]$$

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

$$0.32^n = 0.03$$

$$n \ln 0.32 = \ln 0.03 \Rightarrow n = 3.07 \simeq 4$$

End of Solution

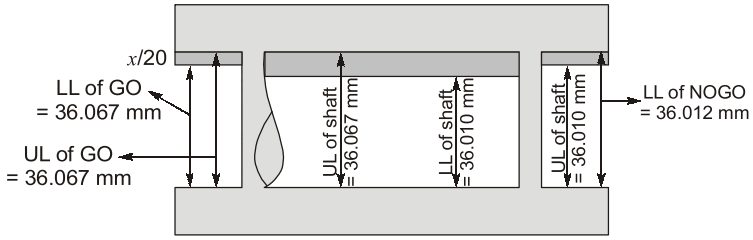
Q.21 'GO' and 'NO GO' snap gauges are to be designed for a shaft $36.000^{+0.070}_{+0.010}$ mm. Gauges tolerance can be taken as 5% of the hole tolerance. Following the ISO system of gauge, the respective sizes of 'GO' and 'NO GO' gauges are:

(a) 36.015 mm and 36.065 mm (b) 36.018 mm and 36.062 mm

(c) 36.020 mm and 36.060 mm (d) 36.013 mm and 36.067 mm

Ans. **(d)**

As wear allowance not given we will not consider.



Tolerance of shaft (x) = 36.070 – 36.010

= 0.060 mm

Tolerance of gauge ($x/20$) = 0.003 mm

5(%) given in question

Therefore GO $\Rightarrow$ $36.070^{0}_{-0.003}$ mm

NOGO $\Rightarrow$ $36.010^{+0.003}_{0}$ mm

Ans is (d)

Examiner has used unilateral tolerance system, we also used it.

End of Solution

Q.22 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) $C' = 2C$ (d) $C' = 1.5C$

Ans. (a)

$$C = \frac{D}{Q}\cdot C_0 + \frac{Q}{2}\cdot C_n$$

and at EOQ $$\frac{D}{Q}\cdot C_0 = \frac{Q}{2}\cdot C_n$$

or $$C = Q\cdot C_n$$

$$C' = \frac{D}{Q'}\cdot C_0 + \frac{Q'}{2}\cdot C_n$$

$$Q' = 2Q$$

$$C' = \frac{D}{2Q}\cdot C_0 + \frac{2Q}{2}\cdot C_n$$

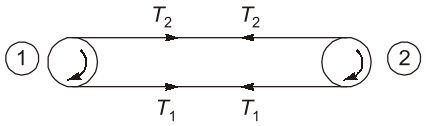
$$C' = \frac{Q}{4}\cdot C_n + Q\cdot C_n = \frac{5}{4}\cdot Q\cdot C_n$$

$$C' = 1.25\ C$$

End of Solution

Q.23 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]

Ans. 9549.3 (9549.1 to 9549.4)



$b = 150$ mm, Power = 15 kW

$$\text{Power} = (T_1 - T_2)\times V$$

$$10^3 \times 15 = (T_1 - T_2)\frac{\pi D_1 N_1}{60}$$

$$(T_1 - T_2) = 9549.3\ \text{N}$$

End of Solution

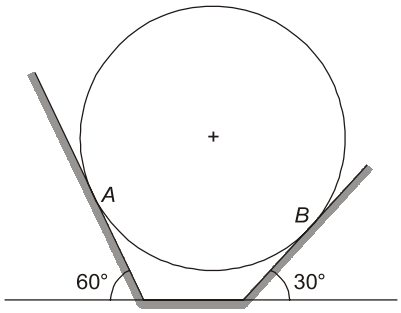
Q.24 Which one among the following mechanisms is NOT used for transforming rotation to translation in machine tools?

(a) Screw-nut system
(b) 4-bevel gear type differential mechanism
(c) Cam and cam follower system
(d) Whitworth mechanism

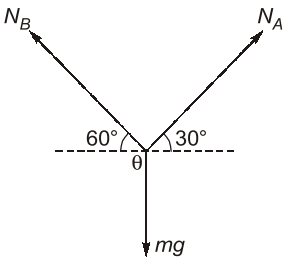
Ans. (b)

End of Solution

Q.25 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 $g = 9.81\ m/s^2$ and consider both sphere and inclines to be rigid)_____. [round off to 2 decimal places]



Ans. 147.15 (147 to 147.30)



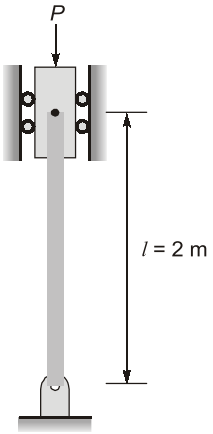
Using sine rule:

$$\frac{N_A}{\sin(90+60)} = \frac{30\times 9.81}{\sin 90^\circ}$$

$$\Rightarrow \quad N_A = 147.15\ N$$

End of Solution

Q.26 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) 4935 (b) 5167
(c) 2000 (d) 1238

Ans. (a)

$$EI = 2000 \text{ Nm}^2$$

$$P_e = \frac{\pi^2 EI}{L^2} = \frac{\pi^2 * 2000}{4} = 4934.80$$

End of Solution

Q.27 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 convex function
(c) A horizontal line (d) An inverted S-shaped curve

Ans. (b)

End of Solution

Q.28 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) 0.6866 (b) 0.8866
(c) 0.7866 (d) 0.5866

Ans. (c)

$$\text{Reliability} = \int_t^\infty \text{Failure prob. } dt$$

$$R(t) = \int_t^\infty F(t).dt$$

Since exponential distribution,

$$f(t) = \lambda e^{-\lambda t}, \quad \lambda = 0.00006 \text{ Hr.}$$

$$R(t) = \int_{4000}^{\infty} F(t).dt = \frac{\lambda e^{-\lambda t}}{-\lambda}\Big|_{4000}^{\infty} = -e^{-\infty} + e^{-\lambda \times 4000}$$

$$\approx 0.7866$$

Alternative solution:

$$R = e^{-\lambda T} = e^{-0.00006 \times 4000} = 0.7866$$

End of Solution

Q.29 Match the component with the corresponding manufacturing process in the table below.

	Component		Manufacturing process
P	Aluminium 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-2, Q-3, R-4, S-1
(d) P-3, Q-4, R-2, S-1

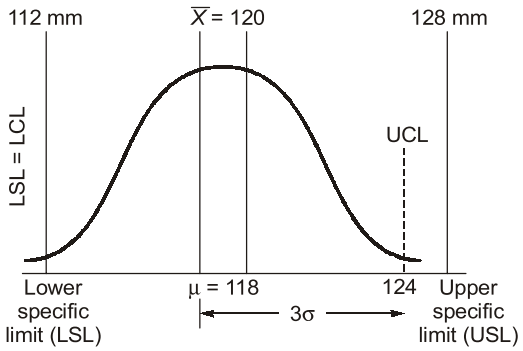
Ans. (d)

End of Solution

Q.30 An in-control process has an estimated standard deviation of 2 mm. The specification limits of the component being processed are 120 ± 8 mm. When the process mean shifts to 118 mm. The values of the process capability indices, C_p and C_{pk}, respectively are:

(a) 1.333, 1.667
(b) 1.000, 1.667
(c) 1.000, 1.000
(d) 1.333, 1.000

Ans. (d)



$$c_p = \frac{USL - LSL}{6\sigma} = \frac{128 - 112}{6 \times 2} = \frac{16}{12} = 1.333$$

$$c_{pk} = \min\left\{\frac{USL - \mu}{3\sigma}, \frac{\mu - LSL}{3\sigma}\right\} = \min\left\{\frac{128 - 118}{3 \times 2}, \frac{118 - 112}{3 \times 2}\right\}$$

$$= \min\left\{\frac{10}{6}, \frac{6}{6}\right\} = 1$$

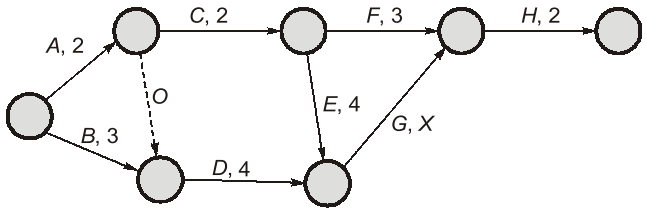
End of Solution

Q.31 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 the value of X (in days) is____. [in integer]

Ans. (5)



$10 + X = 15 \Rightarrow X = 5$ days

End of Solution

Q.32 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) 2.50
(c) 0.60 (d) 0.67

Ans. (c)

$$f = 10 \text{ kHz}$$

$$\text{Pulse time} = \frac{1}{10000} S = 100\ \mu s$$

$$\text{Pulse off time} = 40\ \mu s$$

$$\therefore \quad \text{duty factor} = \frac{\text{Pulse on time}}{\text{Total time}}$$

$$= \frac{100-40}{100} = 0.6$$

End of Solution

Q.33 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/mK 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]

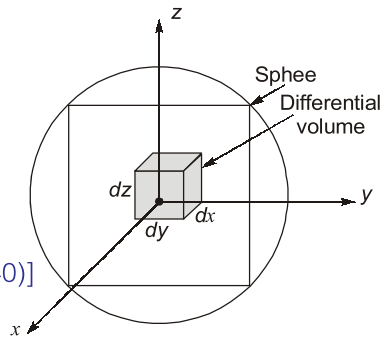
Ans. **20943.9 (20943.8 to 20944.1)**

Temperature field $T(x, y, z) = 100 - 70 + 51y - 80z - 10x^2 - 20y^2 - 20z^2$

Thermal conductivity (K) = 50 W/mK

From Fourier law,

$$\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2} + \frac{\dot{q}_{gen}}{k} = 0$$



$$\dot{q}_{gen} = -k\left[\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2}\right]$$

$$= -k[-20) + (-40) + (-40)]$$

$$= -50 \times (-100)$$

$$\dot{q}_{gen} = 5000 \text{ W/m}^3$$

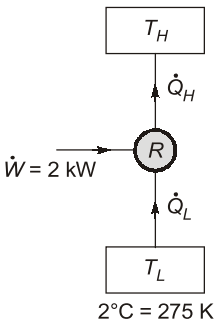
$$Q = \dot{q}_{gen} \times \frac{4}{3}\pi R^3 = 5000 \times \frac{4}{3}\pi \times 1^3$$

$$Q = 20943.9 \text{ Watt}$$

End of Solution

Q.34 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]

Ans. **2.5 (2.4 to 2.6)**



$$\dot{Q}_L = 300 \text{ kJ/min}$$

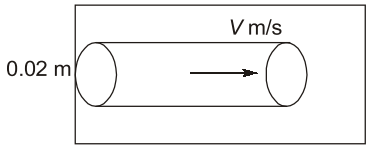
$$= 5 \text{ kJ/s}$$

$$(COP)_{Ref} = \frac{KC}{\dot{W}_{I/P}} = \frac{\dot{Q}_L}{\dot{W}_{I/P}} = \frac{5}{2} = 2.5$$

End of Solution

Q.35 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]

Ans. 0.198 (0.193 to 0.203)



$$\text{Crosssection} = dt$$

$$\text{Metal Melting rate} = dt\ v \text{ m/s}$$

$$\text{Mass melting ratio } (\dot{m}) = \frac{0.2}{1000} \times \frac{3}{1000} \times v \times 8000 \text{ kg/m}^3$$

$$= 0.0048\ V \text{ kg/s}$$

$$\text{Power required} = \dot{m}L + \dot{m}c_p\Delta T = 2000\ W \times 0.5$$

$$\dot{m}(L + c_p\Delta T) = 1000$$

or $0.0048\ V\ \{(3 \times 10^5 + 500 \times (1530 - 30\} = 1000$

or $V = 0.198$ m/s

End of Solution

Q.36 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-1, Q-3, R-4, S-2
(b) P-4, Q-3, R-1, S-2
(c) P-2, Q-4, R-3, S-1
(d) P-4, Q-1, R-2, S-3

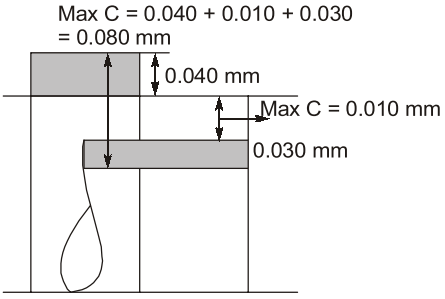
Ans. (b)

End of Solution

Q.37 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) 0.08
(b) 0.04
(c) 0.05
(d) 0.10

Ans. (a)



End of Solution

Q.38 The probability mass function $P(x)$ of a discrete random variable X is given by $P(x) = \frac{1}{2^x}$, where $x = 1, 2, \ldots \infty$. The expected value of X is_____.[in integer]

Ans. 2 (2 to 2)

Since $p(x)$ is discrete for,

$$p(x) = \frac{1}{2^x}, \quad (x = 1, 2, \ldots \infty)$$

$$E(x) = \sum_{x=1}^{\infty} xp(x) = 1\times\frac{1}{2} + 2\times\frac{1}{2^2} + 3\times\frac{1}{2^3} + 4\times\frac{1}{2^4} + \ldots + \infty$$

Series converges to ≈ 2.

Alternative solution:

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

Expected value $= \Sigma x_i P_i$

Dividing by 2
$$\frac{S}{2} = \left(1\cdot\frac{1}{2}\right) + \left(2\cdot\frac{1}{2^2}\right) + \left(3\cdot\frac{1}{2^3}\right) + \left(4\cdot\frac{1}{2^4}\right) + \ldots \quad \ldots(i)$$

$$\frac{S}{2} = \left(1\cdot\frac{1}{2^2}\right) + \left(2\cdot\frac{1}{2^3}\right) + \left(3\cdot\frac{1}{2^4}\right) + \ldots \quad \ldots(ii)$$

Subtracting (i) and (ii) we get...

$$S - \frac{S}{2} = \frac{1}{2} + \frac{1}{2^2} + \frac{1}{2^3} + \frac{1}{2^4} + \ldots$$

$$\frac{S}{2} = \frac{\frac{1}{2}}{1-\frac{1}{2}} = 1$$

$$S = 2$$

End of Solution

ESE 2021

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Mode: Live/Online & Offline

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Duration
75 days

Total 275-300
Teaching hours

Streams:
CE, ME, EE, E&T

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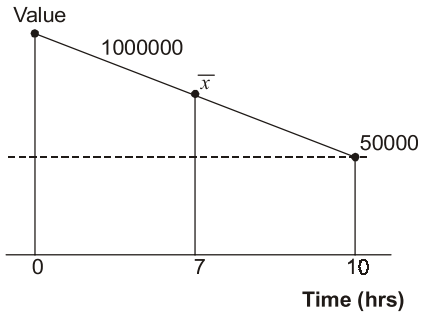
Q.39 The initial cost of a machine is INR 10,00,000 and its salvage value after 10 years of use is INR 50,000. Using the straight line depreciation method, the book value in INR of the machine at the end of 7th year is_____. [in integer]

Ans. 335000 (335000 to 335000)



x = ?

$$\text{Annual depreciation} = \frac{\text{Purchse} - \text{Salvage}}{\text{Useful life}} = \frac{1000000 - 50000}{10}$$

$$= \text{Rs.}95000$$

$$\text{Book value} = 1000000 - 7 \times 95000 = \text{Rs.}335000$$

End of Solution

Q.40 A single point cutting tool with 15° orthogonal take 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]

Ans. (29.0) (28 to 30)

Given: $\alpha = 15°$, $t = 0.9$ mm, $t_c = 1.8$ mm,

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

$$\tan\phi = \frac{0.5\cos 15°}{1 - 0.5\sin 15°} \Rightarrow \phi = 29.02°$$

$$= 29.0$$

End of Solution

Q.41 Which one of the following defects is NOT associated with welding processes?

(a) Hot tear
(b) Hydrogen embrittlement
(c) Angular distortion
(d) Earring

Ans. (d)

Earing defect is related to sheet metal operation. Remaining are related to welding.

End of Solution

Q.42 The eigen values 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 I is 2×2 identify matrix, its eigenvalues are

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

Ans. **(b)**

Eigen values of matrix A = 5, 10
Eigen values of matrix B = Eigen value of $(A + \alpha I)$
Eigen values of indentify matrix, I = 1, 1
$\therefore$ Eigen values of matrix $B = 5 + \alpha$, $10 + \alpha$

End of Solution

Q.43 Pearlite microstructure in an eutectoid steel consists of alternating layers of two phases, namely α ferrite and

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

Ans. **(b)**

End of Solution

Q.44 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 Chvorinov's equation $t = B\left[\frac{V}{A}\right]^2$ where B is the mold constant, and V 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]

Ans. **(75.07) (74.5 to 75.5)**

Initial casting: D_1 = 1 m
$(\text{Bigger casting})_B$, h_1 = 50 mm = 0.05 m
Modified casting (m), D_2 = 0.5 m
h_2 = 25 mm = 0.025 m

$$t_s = B\left(\frac{V}{A}\right)_B^2 \Rightarrow t_s \alpha \left(\frac{V}{A}\right)_B^2$$

$$\left(\frac{V}{A}\right)_B^2 = \left[\frac{\frac{\pi}{4}(1)^2 \times 0.05}{2.\frac{\pi}{4}(1)^2 + \pi(1)(0.05)}\right]^2 = 0.0005165$$

$$\left(\frac{V}{A}\right)_M^2 = \left[\frac{\frac{\pi}{4}(0.5)^2 \times 0.025}{2\frac{\pi}{4}(0.5)^2 + \pi(0.5)0.025}\right]^2 = 0.0001288$$

% reduction in solidification time.

$$\frac{(t_s)_B - (t_s)_m}{(t_s)_B} = \frac{\left(\frac{V}{A}\right)_B^2 - \left(\frac{V}{A}\right)_M^2}{\left(\frac{V}{A}\right)_B^2}$$

$$= \left(\frac{0.0005165 - 0.0001288}{0.0005165}\right)$$

$$= 0.7507$$

$$= 75.07\%$$

End of Solution

Q.45 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 $\sigma_d = \bar{\sigma}\ln\left[\frac{1}{1-r}\right]$, 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 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]

Ans. (16.82) (16.80 to 16.84)

$$\sigma_d = \bar{\sigma}_o \ln\left(\frac{1}{1-r}\right)$$

$$r = \frac{A_o - A_f}{A_o} = 1 - \frac{A_f}{A_o}$$

$$1 - r = \frac{A_f}{A_o}$$

$$\frac{1}{1-r} = \frac{A_o}{A_f} = \frac{\pi d_o^2/4}{\pi d_f^2/4} = \frac{d_o^2}{d_f^2}$$

$$\ln\left(\frac{1}{1-r}\right) = 2\ln\left(\frac{d_o}{d_f}\right)$$

$$\sigma_d = \bar{\sigma}_o \times 2\ln\left(\frac{d_o}{d_f}\right) = 600 \times 2\ln\left(\frac{5}{4}\right)$$

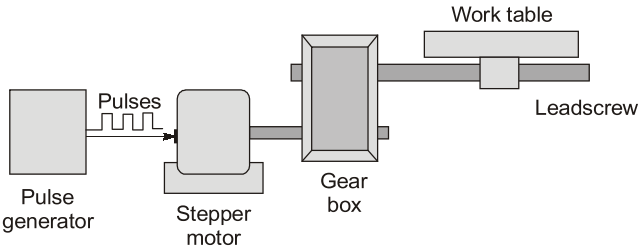
$$= 267.77 \text{ MPa}$$

Formula used by examiner is wrong, $\sigma_d = \sigma_0 \ln\left(\frac{A_f}{A_o}\right) = 2\sigma_0 \ln\left(\frac{d_f}{d_o}\right)$

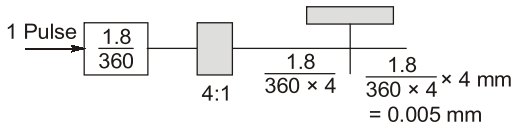
$$\text{Force} = \sigma_d \times A_f$$
$$\text{Power} = \sigma_d \times A_f \times \theta$$
$$= 267.77 \times \frac{\pi \times 4^2}{4} \times 5$$
$$= 16824 \text{ W} \approx 16.82 \text{ kW}$$

End of Solution

Q.46 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]



Ans. (2000) (1999 to 2001)



For 0.005 mm movement 1 pulse required

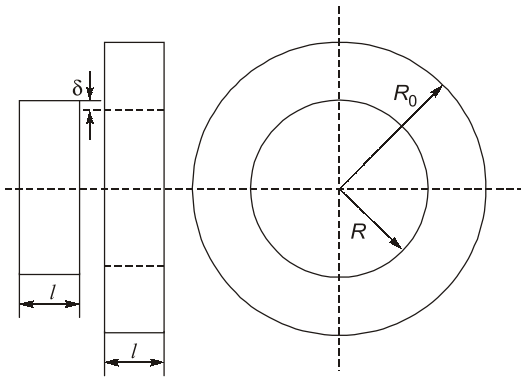
For 1 mm movement $\frac{1}{0.005}$ pulse required

For 10 mm/s movement $\frac{10}{0.005}$ pulse required

$= 2000$ pulse/s $= 2000$ Hz

End of Solution

Q.47 Two cylindrical parts of equal length l, as shown in die figure, made of steel having Young's modulus, $E = 200$ GPa and Poisson's ratio, $\nu = 0.33$ are press fitted upon one another. If radial interference, $\delta = 0.05$ mm, and radii $R = 25$ mm and $R_0 = 40$ mm, then the contact pressure P in MPa at the interface upon press fit is



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

Ans. (b)

Radial clearance required,

$$\Rightarrow \quad A_i = d_i \times \left[\frac{(\sigma_h)_{\text{outer cylinder}} + (\sigma_h)_{\text{inner cylinder}}}{E}\right] \quad \text{... (i)}$$

For outer cylinder (internal contact pressure):

$$\sigma_h = P_i \times \frac{d_i}{d^2}\left[\frac{d_o^2 + d^2}{d_o^2 - d_i^2}\right]$$

At, $d = d_i = 25$ mm and $d_o = 40$ mm

$$(\sigma_h)_o = P^2 \times \frac{\left(40^2 + 25^2\right)}{40^2 - 25^2} = 2.282P \quad \text{... (ii)}$$

For inner cylinder,

$$(\sigma_h)_i = P \text{ (Compressive)}$$

$$0.05 = 25 \times \left[\frac{2.282P + P}{200 \times 10^3}\right] \quad \text{... [From equation (i) and (ii)]}$$

$$\Rightarrow \quad P = 121.877 \text{ MPa} \approx 121.9 \text{ MPa}$$

End of Solution

Q.48 In a turning operation, doubling the cutting speed (V) reduces the tool life (T) to $(1/8)^{th}$ of the original tool life. The exponent n in the Taylor's tool life equation.
$VT^n = C$ is

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

Ans. (c)

$$V_2 = 2V_1$$

$$T_2 = \frac{T_1}{8}$$

$$V_1 T_1^n = V_2 T_2^n = 2V_1 \times \left(\frac{T_1}{8}\right)^n$$

$$1 = 2 \times \frac{1}{8^n}$$

$$8^n = 2$$

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

End of Solution

Q.49 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]

Ans. **(1.90) (1.85 to 1.95)**

Given: $h_0 = 3.5$ mm, $D = 500$ mm, $R = 250$ mm, $N = 200$ rpm, $\mu = 0.08$, $\bar{\sigma}_o = 400$ MPa

$$h_o - h_{f\,min} = \mu^2 R$$
$$3.5 - h_{f\,min} = (0.08)^2 \times 250$$
$$h_{f\,min} = 1.9 \text{ mm}$$

End of Solution

Q.50 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]

Ans. **2100 (2100 to 2100)**

$$\text{Tighting torque} = F_{Pre}\left(\frac{d}{2}\right)\tan(\phi + \alpha)$$

$$\text{Torque} = F_{pre}\frac{d}{2}\tan(\phi + \alpha)$$

$$\frac{d}{2}\tan(\phi + \alpha) = \text{Torque coefficient}$$

$$\text{Torque} = F_{pre}\, d.k = 350 \times 30 \times 0.2$$
$$= 2100 \text{ N-m}$$

End of Solution

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Q.51 If $(3i+1)x + (4i+4)y + 5 = 0$ with x, y being real and $i = \sqrt{-1}$, then $x =$ _____. [correct upto one decimal place]

Ans. **2.5 (2.4 to 2.6)**

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

$x + 4y + 5 = 0$ ... (i)

$3x + 4y = 0$ ... (ii)

$3x + 4y = 0$

$x + 4y = -5$

After solving (i) and (ii), $x = 2.5$

End of Solution

Q.52 Which one of the following is an improvement type heuristic algorithm for computerized layout design technique?

(a) Plant layout analysis and evaluation technique (PLANET)
(b) Computerized relative allocation of facilities technique (CRAFT)
(c) Systematic layout planning (SLP)
(d) Computerized relationship layout planning (CORELAP)

Ans. **(b)**

End of Solution

Q.53 In a typical product development process under concurrent engineering approach, all elements of product life cycle from conception to disposal are considered at

(a) Product design stage
(b) Manufacturing stage
(c) Disposal stage
(d) Process design stage

Ans. **(a)**

End of Solution

Q.54 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]

Ans. **0.368 (0.365 to 0.370)**

t = The time to pass a security screening at an airport follows exponential distribution.

Given: $\frac{1}{\lambda}$ = Mean = 15 $\Rightarrow \lambda = \frac{1}{15}$

p.d.f. $f(t) = \begin{cases} \lambda e^{-\lambda t}, & t \geq 0 \\ 0, & \text{Else} \end{cases}$

Prob that passenger will miss flight,

$= P(t > 15) = P$(Screening time is more than 15 min)

$$= 1 - P(t \le 15) = 1 - \int_0^{15} \lambda e^{-\lambda t} dt = 1 - \lambda \frac{e^{-\lambda t}}{-\lambda}\Big|_0^{15} = 1 + \left[e^{-15\lambda} - 1\right]$$

$$= e^{-15(1/15)} \qquad \left[\because \lambda = \frac{1}{15}\right]$$

$$= e^{-1} = \frac{1}{e} = 0.368$$

End of Solution

Q.55 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) 111.4 mm (b) 154.1 mm

(c) 128.3 mm (d) 89.1 mm

Ans. (*)

Given: d = 0.003 m, ρ = 900 kg/m^3, σ = 0.1 N/m, θ = 30°, g = 10 m/s^2

Rise in height in capillary = $\frac{4\sigma\cos\theta}{d\rho g} = \frac{4\times 0.1\times \cos 30^\circ}{0.003\times 900\times 10}$

= 0.01284 m = 12.83 mm

Note: No answer giving in the options are matching.

End of Solution

■■■■