

Q. 1 – Q. 5 carry one mark each.

Q.1 The fishermen, _____ the flood victims owed their lives, were rewarded by the government.

- (A) whom (B) to which (C) to whom (D) that

Q.2 Some students were not involved in the strike.

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

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

- (A) 1 and 2 (B) 3 (C) 4 (D) 2 and 3

Q.3 The radius as well as the height of a circular cone increases by 10%. The percentage increase in its volume is _____.

- (A) 17.1 (B) 21.0 (C) 33.1 (D) 72.8

Q.4 Five numbers 10, 7, 5, 4 and 2 are to be arranged in a sequence from left to right following the directions given below:

1. No two odd or even numbers are next to each other.
2. The second number from the left is exactly half of the left-most number.
3. The middle number is exactly twice the right-most number.

Which is the second number from the right?

- (A) 2 (B) 4 (C) 7 (D) 10

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

- (A) defeated (B) defeating (C) defeat (D) defeatist

Q. 6 – Q. 10 carry two marks each.

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

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

- (A) Whenever the Reserve Bank of India reduces the repo rate, the interest rates on small saving schemes are also reduced
- (B) Interest rates on small saving schemes are always maintained on par with fixed deposit interest rates
- (C) The government sometimes takes into consideration the demands of banking institutions before reducing the interest rates on small saving schemes
- (D) A reduction in interest rates on small saving schemes follow only after a reduction in repo rate by the Reserve Bank of India

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

- (A) 10.50 (B) 14.70 (C) 15.00 (D) 50.00

- Q.8 The nomenclature of Hindustani music has changed over the centuries. Since the medieval period *dhrupad* styles were identified as *baanis*. Terms like *gayaki* and *baaj* were used to refer to vocal and instrumental styles, respectively. With the institutionalization of music education the term *gharana* became acceptable. *Gharana* originally referred to hereditary musicians from a particular lineage, including disciples and grand disciples.

Which one of the following pairings is NOT correct?

- (A) *dhrupad*, *baani*
- (B) *gayaki*, vocal
- (C) *baaj*, institution
- (D) *gharana*, lineage

- Q.9 Two trains started at 7AM from the same point. The first train travelled north at a speed of 80km/h and the second train travelled south at a speed of 100 km/h. The time at which they were 540 km apart is _____ AM.

- (A) 9 (B) 10 (C) 11 (D) 11.30

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

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

- (A) the prestige of the kingdom
- (B) the prestige of the heads
- (C) the number of taxes he could levy
- (D) the number of heads he could gather

END OF THE QUESTION PAPER

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Q. 1 – Q. 25 carry one mark each.

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

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

Q.2 For a complex number $z = 1 - 4i$ with $i = \sqrt{-1}$, the value of $\left| \frac{z+3}{z-1} \right|$ is

- (A) 0 (B) $1/\sqrt{2}$ (C) 1 (D) $\sqrt{2}$

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

- (A) $2\mathbf{i} - 3\mathbf{j} + 8\mathbf{k}$ (B) $2\mathbf{i} + 3\mathbf{j} + 4\mathbf{k}$
(C) $7\mathbf{i} - 3\mathbf{j} + 8\mathbf{k}$ (D) $7\mathbf{i} - 5\mathbf{j} + 8\mathbf{k}$

Q.4 If roots of the auxiliary equation of $\frac{d^2y}{dx^2} + a\frac{dy}{dx} + by = 0$ are real and equal, the general solution of the differential equation is

- (A) $y = c_1 e^{-ax/2} + c_2 e^{ax/2}$ (B) $y = (c_1 + c_2 x) e^{-ax/2}$
(C) $y = (c_1 + c_2 \ln x) e^{-ax/2}$ (D) $y = (c_1 \cos x + c_2 \sin x) e^{-ax/2}$

Q.5 The solution of $\int_1^a \int_1^b \frac{dx dy}{xy}$ is

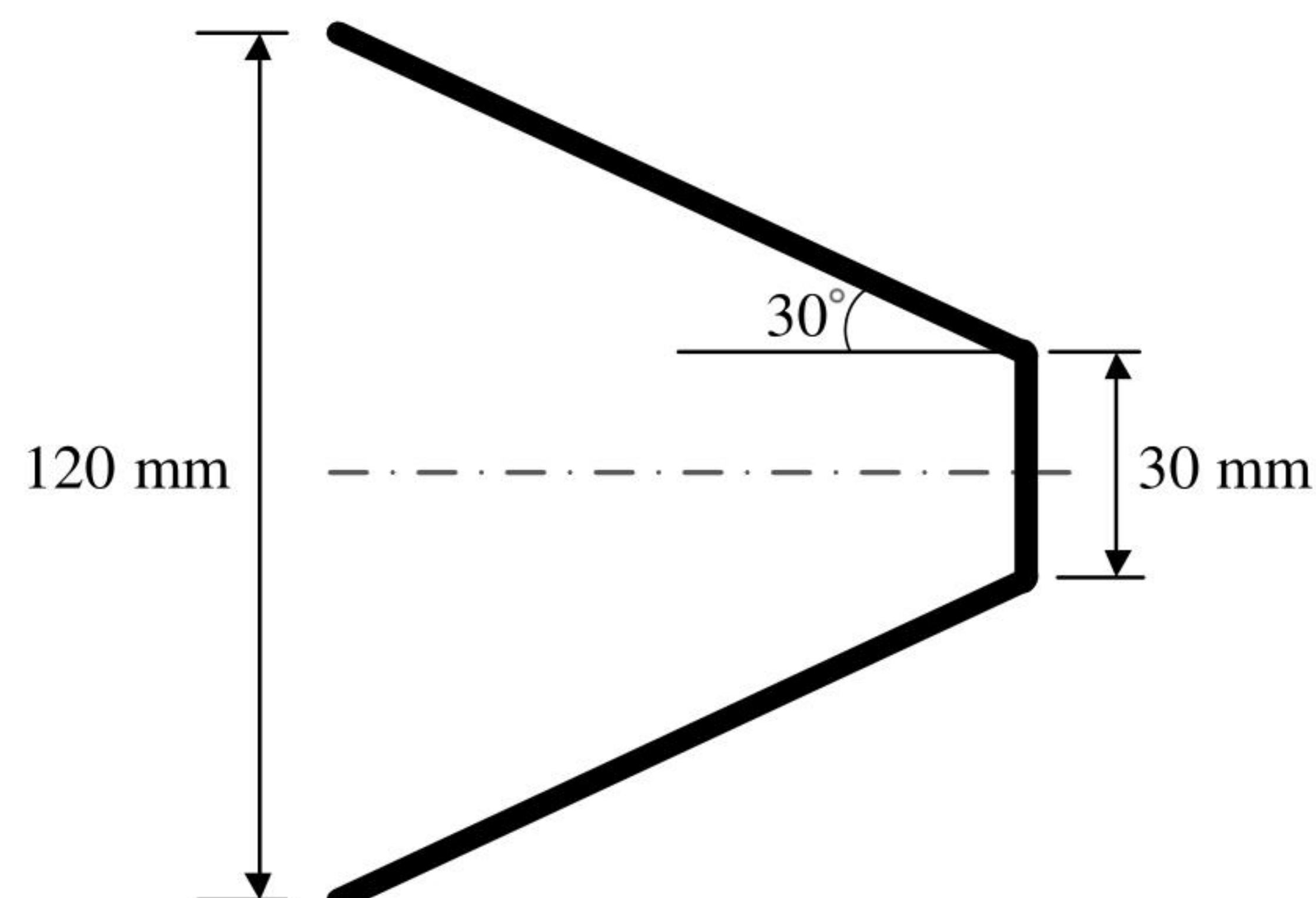
- (A) $\ln(ab)$ (B) $\ln(a/b)$ (C) $\ln(a) + \ln(b)$ (D) $\ln(a)\ln(b)$

- Q.6 Match the crystal structure in **Column A** with the corresponding packing fractions in **Column B** of the table

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

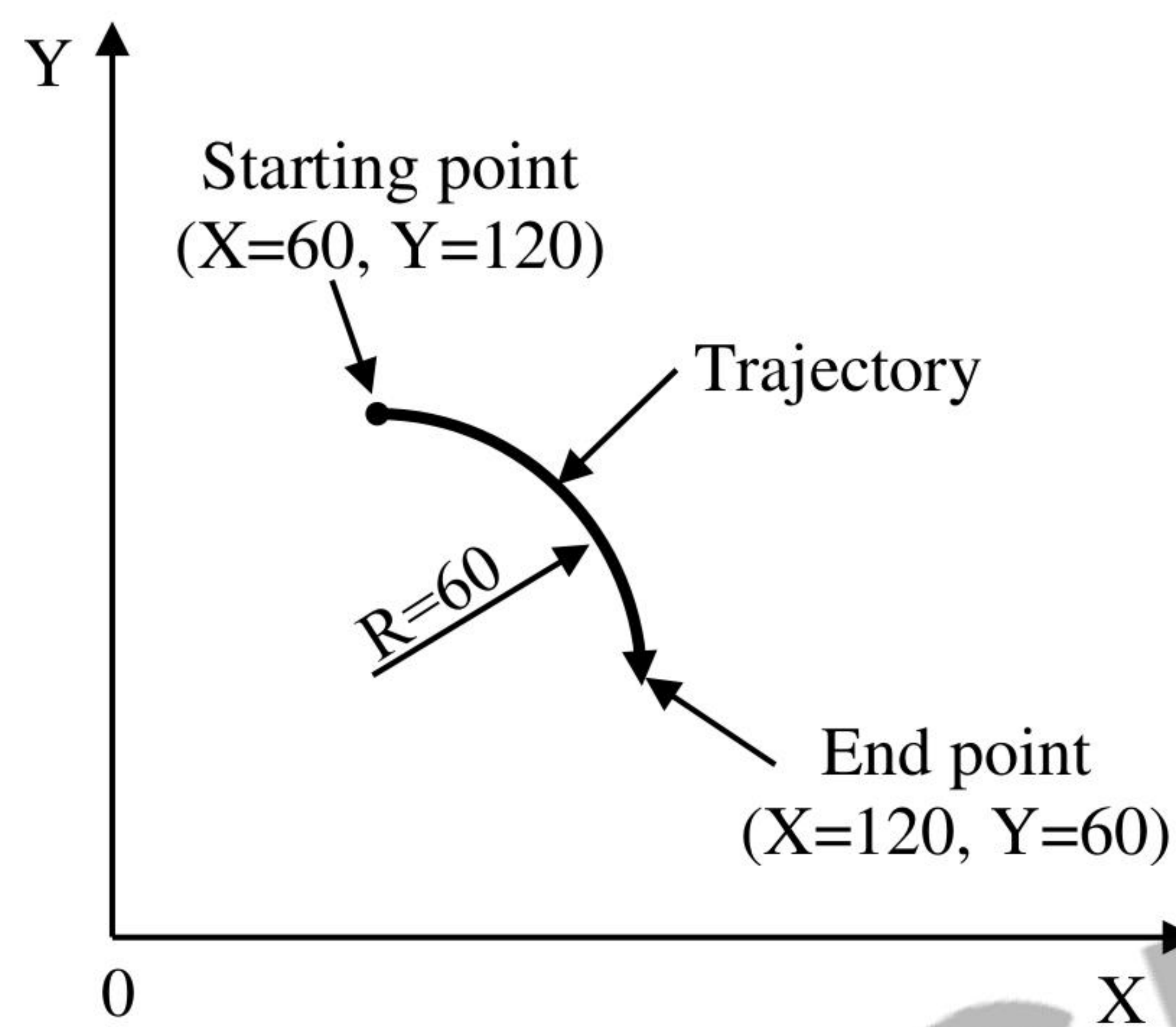
- (A) 1-P, 2-R, 3-Q, 4-Q
 (B) 1-R, 2-P, 3-R, 4-Q
 (C) 1-R, 2-P, 3-Q, 4-P
 (D) 1-P, 2-R, 3-P, 4-Q
- Q.7 The link lengths of a planar four bar mechanism are $AB = 100$ mm, $BC = 25$ mm, $CD = 75$ mm and $DA = 90$ mm. For achieving the full rotation of both the input (crank) as well as the output (follower) links, the link that needs to be fixed is
- (A) AB (B) BC (C) CD (D) DA
- Q.8 The process used for producing continuous insulation coating on an electrical wire is
- (A) Extrusion
 (B) Injection molding
 (C) Blow molding
 (D) Deep drawing
- Q.9 The correct statement pertaining to the friction welding process is
- (A) Heat affected zone is not formed
 (B) Flashes are not produced
 (C) Dissimilar materials cannot be joined
 (D) Melting of the base material(s) is not involved

- Q.10 The end product obtained using spinning process is shown in the figure. The initial blank thickness is 2.5 mm. The blank diameter (in mm) is



- (A) 75 (B) 105 (C) 150 (D) 210
- Q.11 For a classical (Wilson) model of determining economic order quantity (EOQ), the carrying and ordering costs are C_r and C_o , respectively. For an annual demand D , the minimum yearly total inventory cost is
- (A) $\sqrt{DC_oC_r}$ (B) $\sqrt{1.5DC_oC_r}$ (C) $\sqrt{2DC_oC_r}$ (D) $\sqrt{3DC_oC_r}$
- Q.12 A company has purchased an asset by investing Rs.30,000. The useful life of the asset is 5 years and it has no salvage value at the end of its useful life. The depreciation cost (in Rs.) for the 2nd year using sum-of-years-digit (SYD) method is
- (A) 10,000 (B) 8,000 (C) 6,000 (D) 4,000

- Q.13 In a NC milling operation, the tool path is generated using absolute programming for the trajectory shown in the figure



The corresponding block of the NC program is

- (A) G02 X 120.0 Y 60.0 R 60.0;
 - (B) G02 X 60.0 Y 120.0 R 60.0;
 - (C) G03 X 60.0 Y 120.0 R 60.0;
 - (D) G03 X 120.0 Y 60.0 R 60.0;
- Q.14 The SQC chart based on Binomial distribution is
- (A) p chart
 - (B) c chart
 - (C) $\bar{X}$ chart
 - (D) R chart
- Q.15 The capacity of a passenger airline is expressed in terms of
- (A) available seats
 - (B) available miles
 - (C) available sectors
 - (D) available seat miles

Q.16 REL chart is used in

- (A) Quality management
- (B) Inventory management
- (C) Facility management
- (D) Human resource management

Q.17 A metallic rod of diameter d_0 is subjected to the tensile test. The engineering stress and the true stress at fracture are 800 MPa and 900 MPa, respectively. The ratio of the rod diameter at fracture d_f to the initial diameter d_0 is _____ (round off to 2 decimal places)

Q.18 A heat pump is to supply heat at the rate of 10 kW to a building to be maintained at 22 °C. The outside temperature is 2 °C. The minimum power (in kW) required to run the heat pump is _____ (round off to 2 decimal places)

Q.19 One kilogram of air is compressed at constant temperature of 150 °C until its volume is halved. Considering gas constant $R = 0.287$ kJ/kg-K for air, magnitude of heat rejected (in kJ) in the compression process is _____ (round off to 2 decimal places)

Q.20 For the abrasive jet machining process, the ratio of abrasive volume to carrier gas volume is 0.25. Further, the ratio of abrasive density to carrier gas density is 25. The mass ratio of abrasive to the mixture of abrasive and carrier gas is _____ (round off to 2 decimal places)

Q.21 In a typical turning tool life test, the following data are generated for tools A and B:

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

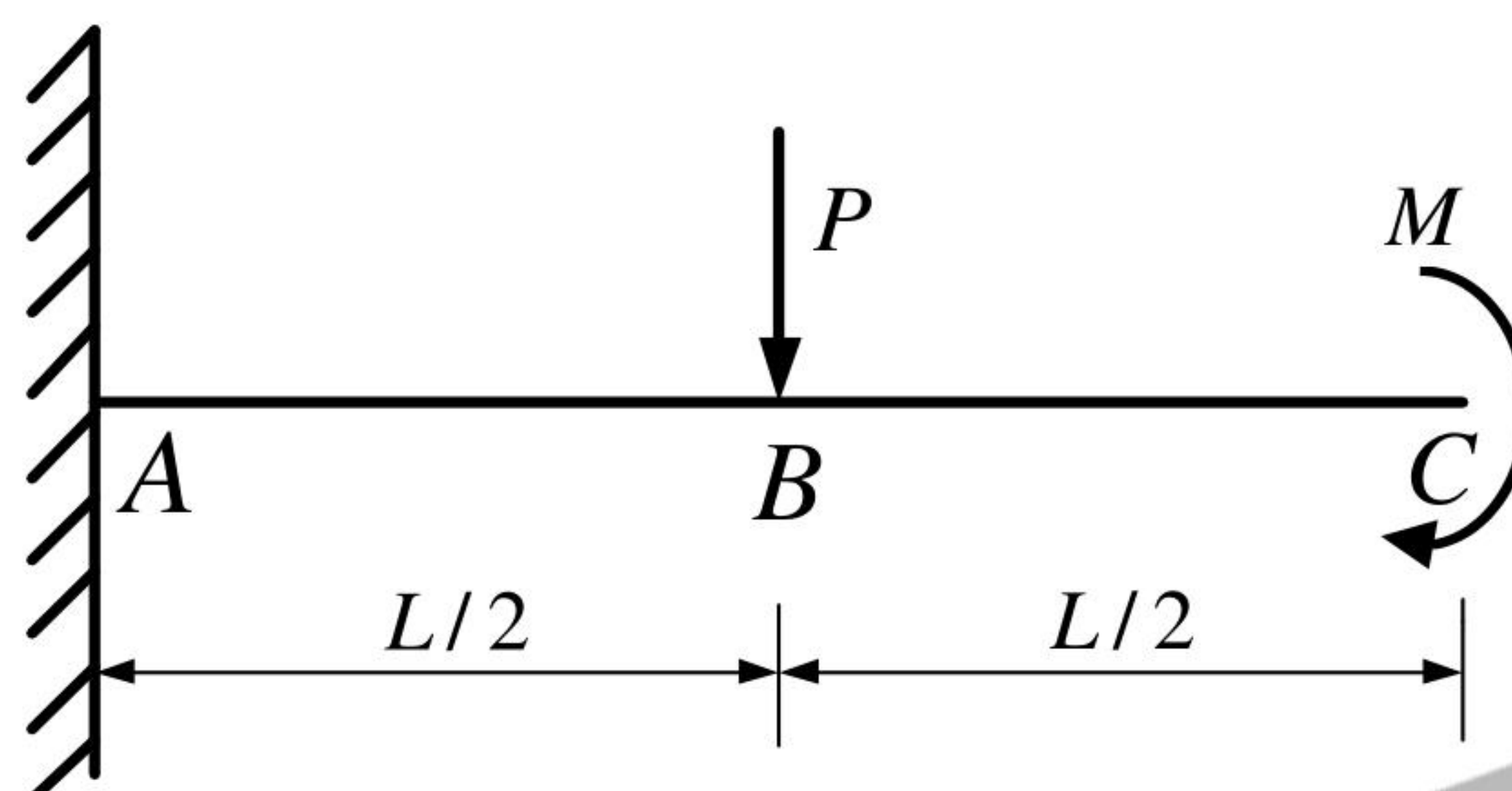
Assuming the same tool life exponent for the tools, the value of constant in the Taylor's tool life equation (with cutting speed in m/min and tool life in min) is _____ (round off to 2 decimal places)

- Q.22 The average proportion non-conforming of 20 samples each of size 100 items is 0.12. The upper control limit for the relevant chart is _____ (round off to 2 decimal places)
- Q.23 For a process which is in a state of statistical control (within $\pm 3\sigma$), estimated process standard deviation (σ) is 3 mm. The specification limits for the corresponding product are 100 ± 7 mm. The capability ratio C_r is _____ (round off to 3 decimal places)
- Q.24 In a work study experiment, normal time was recorded as 140 s with a rating of 100%. Considering 2% allowance, the standard time (in s) is _____ (round off to 1 decimal place)
- Q.25 A warehouse has 1 loading dock and 3 persons for loading operations. The arrival rate of trucks follows Poisson distribution with a mean of 4 trucks/hour. The average loading time (by three persons together) per truck is exponentially distributed with a mean of 10 minutes. The charge of the trucks per hour and loading charges per person per hour are Rs.20 and Rs.6, respectively. The total cost (in Rs./hour) is _____

Q. 26 – Q. 55 carry two marks each.

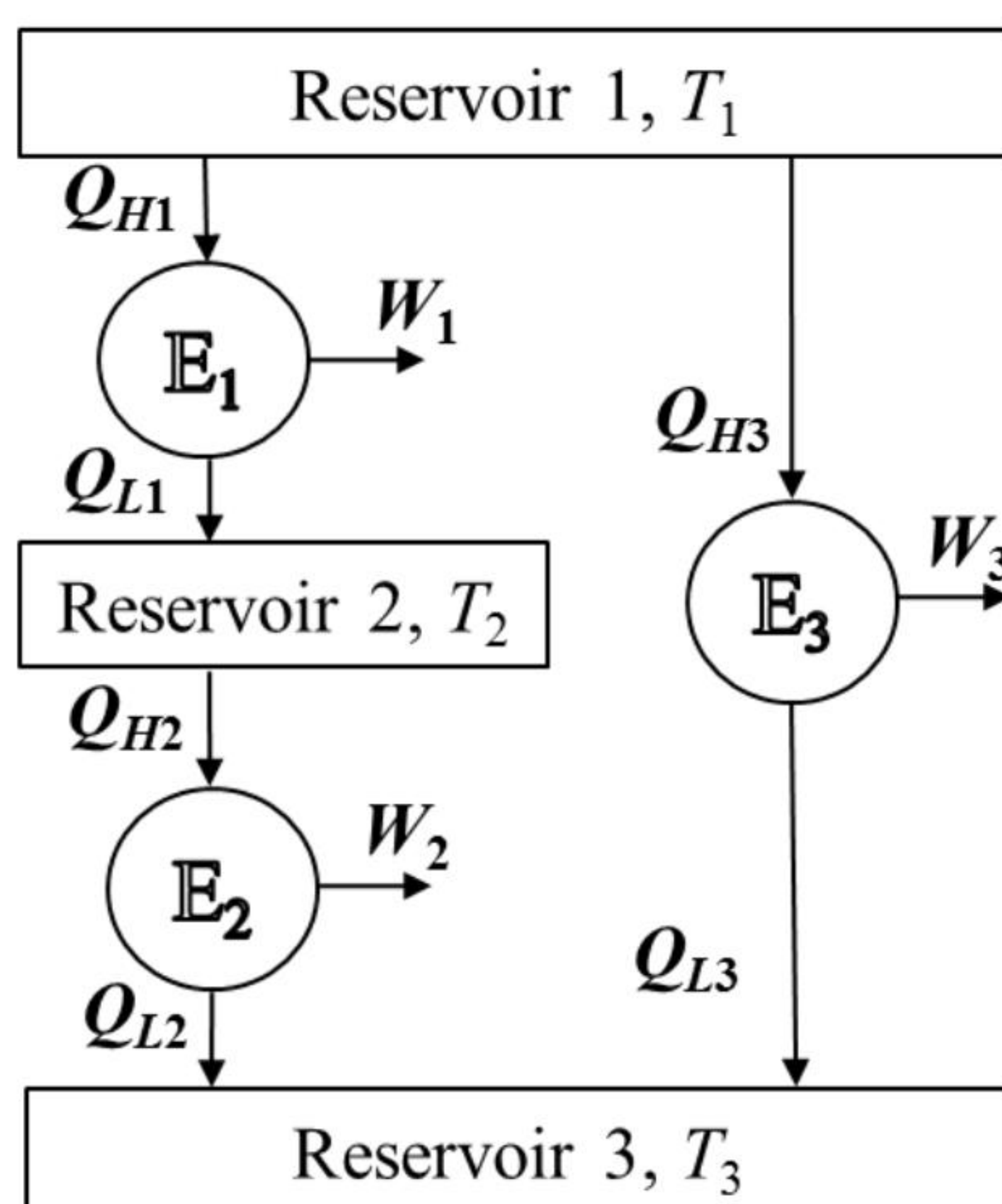
- Q.26 If the Laplace transform of $e^{\omega t}$ is $\frac{1}{s - \omega}$, the Laplace transform of $t \cosh t$ is
- (A) $\frac{1 + s^2}{(s^2 - 1)^2}$ (B) $\frac{st}{(s^2 - 1)}$ (C) $\frac{1 - s^2}{(s^2 - 1)^2}$ (D) $\frac{1 + s^2}{1 - s^2}$
- Q.27 General solution of the Cauchy-Euler equation $x^2 \frac{d^2 y}{dx^2} - 7x \frac{dy}{dx} + 16y = 0$ is
- (A) $y = c_1 x^2 + c_2 x^4$ (B) $y = c_1 x^2 + c_2 x^{-4}$
 (C) $y = (c_1 + c_2 \ln x) x^4$ (D) $y = c_1 x^4 + c_2 x^{-4} \ln x$

- Q.28 A uniform cantilever beam ABC of length L is subjected to a point load P at point B and a concentrated moment M at point C (as shown in figure). Let E be the Young's modulus of the beam material and I be the area moment of inertia of the beam's cross-section. Assuming the validity of the Euler-Bernoulli theory of slender beams, the downward deflection at point C is



- (A) $\frac{PL^3}{3EI} + \frac{ML^2}{2EI}$ (B) $\frac{PL^3}{24EI} + \frac{ML^2}{EI}$ (C) $\frac{PL^3}{48EI} + \frac{ML^2}{2EI}$ (D) $\frac{5PL^3}{48EI} + \frac{ML^2}{2EI}$

- Q.29 Three Carnot engines $\mathbb{E}_1$, $\mathbb{E}_2$, $\mathbb{E}_3$ operate as shown in the figure ($T_1 > T_2 > T_3$).



The efficiency of the engine $\mathbb{E}_3$ in terms of the efficiencies η_1 and η_2 of the engines $\mathbb{E}_1$ and $\mathbb{E}_2$, respectively, is

- (A) $\eta_1 + \eta_2$ (B) $\eta_1 + \eta_2 - \eta_1\eta_2$
(C) $1 - \eta_1 - \eta_2$ (D) $1 - \eta_1\eta_2$

- Q.30 True centrifugal casting process in horizontal configuration is to be used for casting a metallic cylinder with outside diameter 0.275 m and inside diameter 0.250 m. If G-factor (ratio of centrifugal force experienced by the rotating cast metal to its weight) is 65 and acceleration due to gravity is 9.8 m/s^2 , the minimum rotational speed (in rpm) required is closest to
- (A) 325 (B) 650 (C) 975 (D) 1300
- Q.31 In a sine bar, let h denote height of slip gauge and l be the distance between the rollers. The relationship between error in angular measurement ($d\theta$) and errors in the slip gauge combination (dh) and in the spacing of the rollers (dl) is
- (A) $d\theta = \sin \theta \left(\frac{dh}{h} - \frac{dl}{l} \right)$
- (B) $d\theta = \cos \theta \left(\frac{dh}{h} - \frac{dl}{l} \right)$
- (C) $d\theta = \tan \theta \left(\frac{dh}{h} - \frac{dl}{l} \right)$
- (D) $d\theta = \cot \theta \left(\frac{dh}{h} - \frac{dl}{l} \right)$
- Q.32 A 100 mm long cylindrical workpiece of diameter 50 mm is reduced to 25 mm diameter using extrusion process. The flow curve for the metal has strength coefficient as $K = 750 \text{ MPa}$ and the strain hardening co-efficient is 0.15. Assuming no friction and no redundant work, the required ram pressure (in MPa) is closest to
- (A) 164 (B) 364 (C) 428 (D) 950

Q.33 An LPP is defined as

$$\text{Minimize } z = 15x_1 + 12x_2$$

subject to,

$$x_1 + 2x_2 \leq 3$$

$$2x_1 - 4x_2 \leq 5$$

$$x_1, x_2 \geq 0$$

The objective function of the dual of this LPP is

(A) Maximize $w = y_1 + y_2$

(B) Maximize $w = y_1 + 2y_2$

(C) Maximize $w = 2y_1 - 4y_2$

(D) Maximize $w = 3y_1 + 5y_2$

Q.34 A 20 mm HSS drill with a point angle of 118° is used for drilling a through hole on a metallic plate of thickness 100 mm with a cutting speed of 333.33 mm/s and feed of 0.22 mm/rev. Assuming that the drill is touching the surface of the plate at the start, the drilling time (in s) is closest to

(A) 85

(B) 90

(C) 96

(D) 100

Q.35 An acceptance sampling plan is selected with sample size $n = 80$, acceptance number $c = 2$ for a lot size of 10,000 units. The probability of accepting the lot is based on Poisson distribution. Assuming rectification inspection, if incoming lot quality p is 0.03 and mean (λ) is 2.4, the average outgoing quality (AOQ) is closest to

(A) 0.0011

(B) 0.0087

(C) 0.0170

(D) 0.0338

Q.36 The mean time to repair (MTTR) for a repairable system is 30 minutes. When maintenance time changes from 20 minutes to 40 minutes, the net increase in maintainability is closest to

(A) 0.15

(B) 0.25

(C) 0.45

(D) 0.60

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

- (A) 8.38 (B) 7.06 (C) 5.74 (D) 3.10

Q.38 The man-hours required (T_n) to manufacture the n^{th} unit in a plant is given by $T_n = T_1 n^b$, where $b = -0.322$ at the 80% learning rate. If the manufacturing time for the first unit (T_1) is 80 man-hours, the total time (in man-hours) required to manufacture the first 4 units, at 80% learning rate, is

- (A) 322.11 (B) 251.35 (C) 103.76 (D) 51.19

Q.39 A firm, with a production target of 50,000 units/year, has the following data for the selection of a new location for its plant

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

The most economical location for the firm is

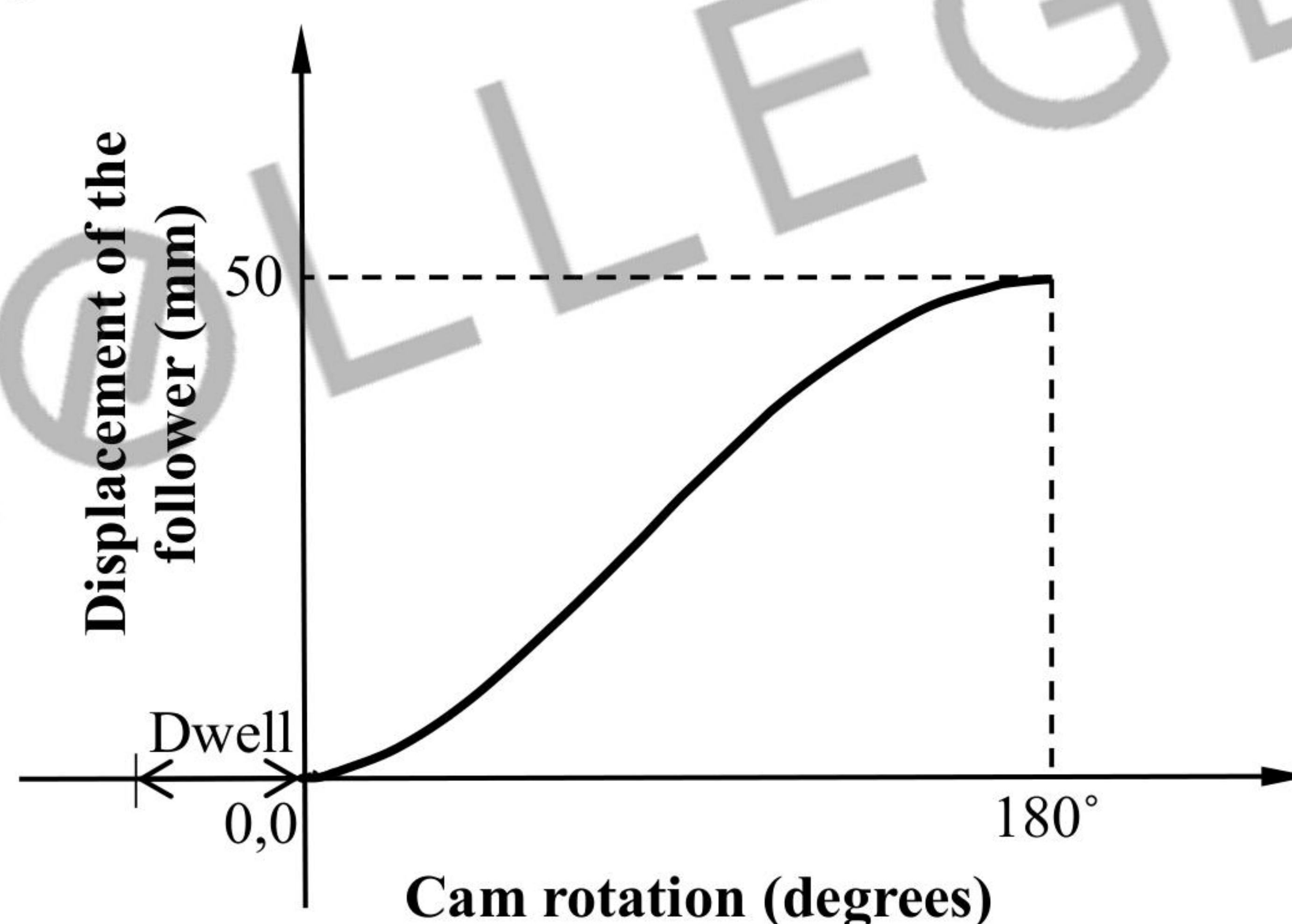
- (A) P (B) Q (C) R (D) S

Q.40 Considering included angle θ of the thread to be 60° using the Best-Wire method, the difference between the effective diameter (E) and the dimension under the wire (T) for M10 $\times$ 1.0 mm is closest to

- (A) 0.289 (B) 0.578 (C) 0.867 (D) 0.982

Q.41 If z is a complex variable with $i = \sqrt{-1}$, the length of the minor axis of an ellipse defined by $|z - (1+i)| + |z - (9+i)| = 10$ is _____

- Q.42 The numerical value of the definite integral $\int_0^1 e^{-x} dx$ using trapezoidal rule with function evaluations at points $x = 0, 0.5$ and 1 is _____ (round off to 3 decimal places)
- Q.43 A thin walled cylindrical pressure vessel with an inside diameter of 300 mm and wall thickness of 3 mm is subjected to an internal gauge pressure of 1.5 MPa. The maximum shear stress (in MPa) at a point located on the inner surface of the pressure vessel is _____
- Q.44 A cam is designed to achieve a simple harmonic motion of a flat-faced follower. Starting from the rest, the follower rises to the maximum height of 50 mm at 180° of cam rotation as shown in the figure.



- If the cam rotates at a uniform angular speed of 100 rpm, the speed of the follower (in mm/s) at the instance when the cam rotates 45° from the initial position is _____
- Q.45 An open tank of $2\text{ m} \times 2\text{ m} \times 2\text{ m}$ is filled with layers of two fluids. Depth of each layer is one meter. The top layer is that of an oil of specific gravity 0.8. The bottom layer is of water. Consider the density of water $\rho_w = 1000\text{ kg/m}^3$ and acceleration due to gravity $g = 9.8\text{ m/s}^2$. Neglecting the effect of atmospheric pressure, the force (in N) exerted by the fluids on one of the side walls of the tank is _____

- Q.46 During a storm, the wind speed is 90 km/hr. In a high-rise building, there is a window of size $1.2 \text{ m} \times 1.8 \text{ m}$ facing the storm on an upper floor. Neglecting the ground effects on wind speed and considering the density of air $\rho_{\text{air}} = 1.2 \text{ kg/m}^3$, the force (in N) acting on the window due to the storm is _____
- Q.47 The heat transfer efficiency in arc welding of a plate using a current of 250 A at 20 V is 90%. The heat required to melt the material is 10 J/mm^3 . If the cross-sectional area of the weld joint is 30 mm^2 and the travel speed is 5 mm/s, the melting efficiency (in %) is _____ (round off to 2 decimal places)
- Q.48 A sand casting process has a mold constant of 2 s/mm^2 and solidification exponent of 2. If the solidification time is to be doubled for a given unit volume of material, the corresponding reduction in the cast surface area (in %) is _____
- Q.49 During a turning operation of a specific work material having shear strength of 220 MPa under orthogonal cutting condition, the process parameters are

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

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

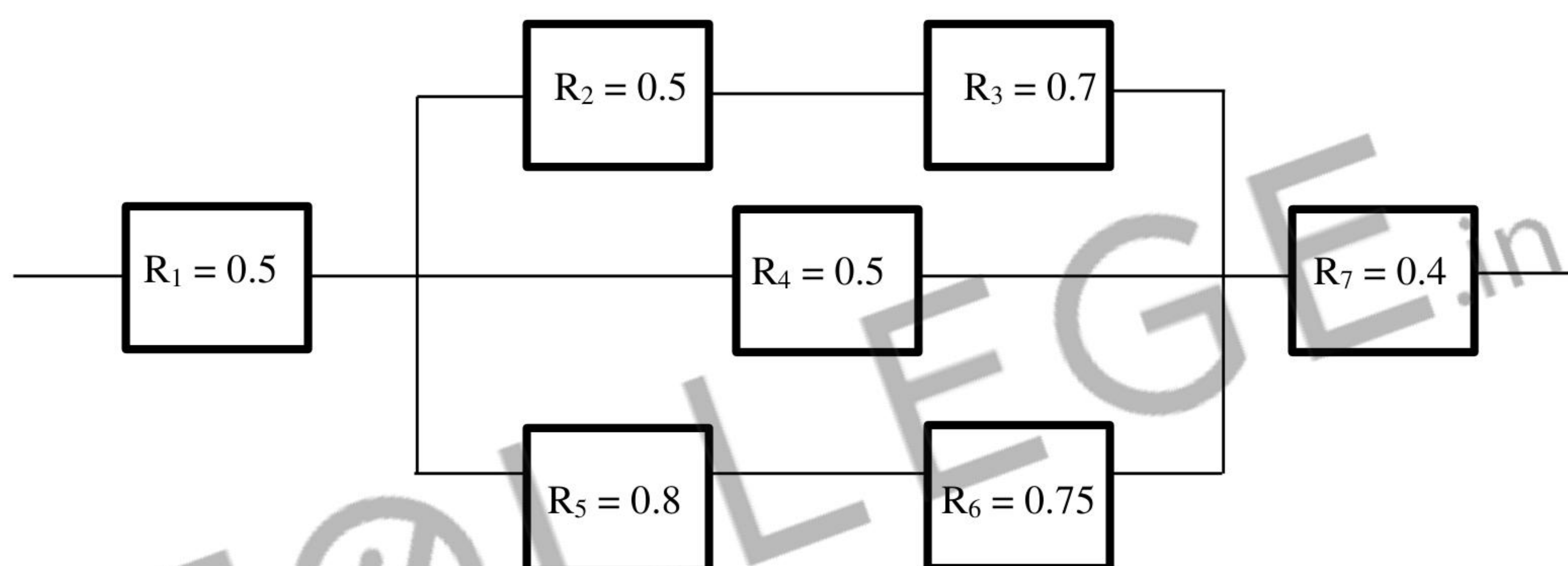
- Q.50 A CO_2 laser in continuous mode is used for drilling a plate. The process parameters and their values are

Laser power intensity	$1 \times 10^8 \text{ W/mm}^2$
Vaporization energy	$5 \times 10^6 \text{ J/mm}^3$
Efficiency of the process	15 %
Laser spot diameter	200 micrometer

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

Q.51 A process which is in a state of statistical control (within $\pm 3\sigma$) has an estimate of standard deviation (σ) 2 mm. The specification limits for the corresponding product are 120 ± 8 mm. When process mean shifts from 118 mm to 122 mm with no change in process standard deviation, the difference in process capability index C_{pk} is _____

Q.52 A monitoring system has seven components. The reliability of each component is shown in the figure. The system reliability is _____ (round off to 2 decimal places)



Q.53 A PERT project network consists of 5 activities A to E. The time estimates of these activities follow Beta-distribution. The predecessor–successor (P-S) relationships between the nodes and time estimates of activities are given in table.

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

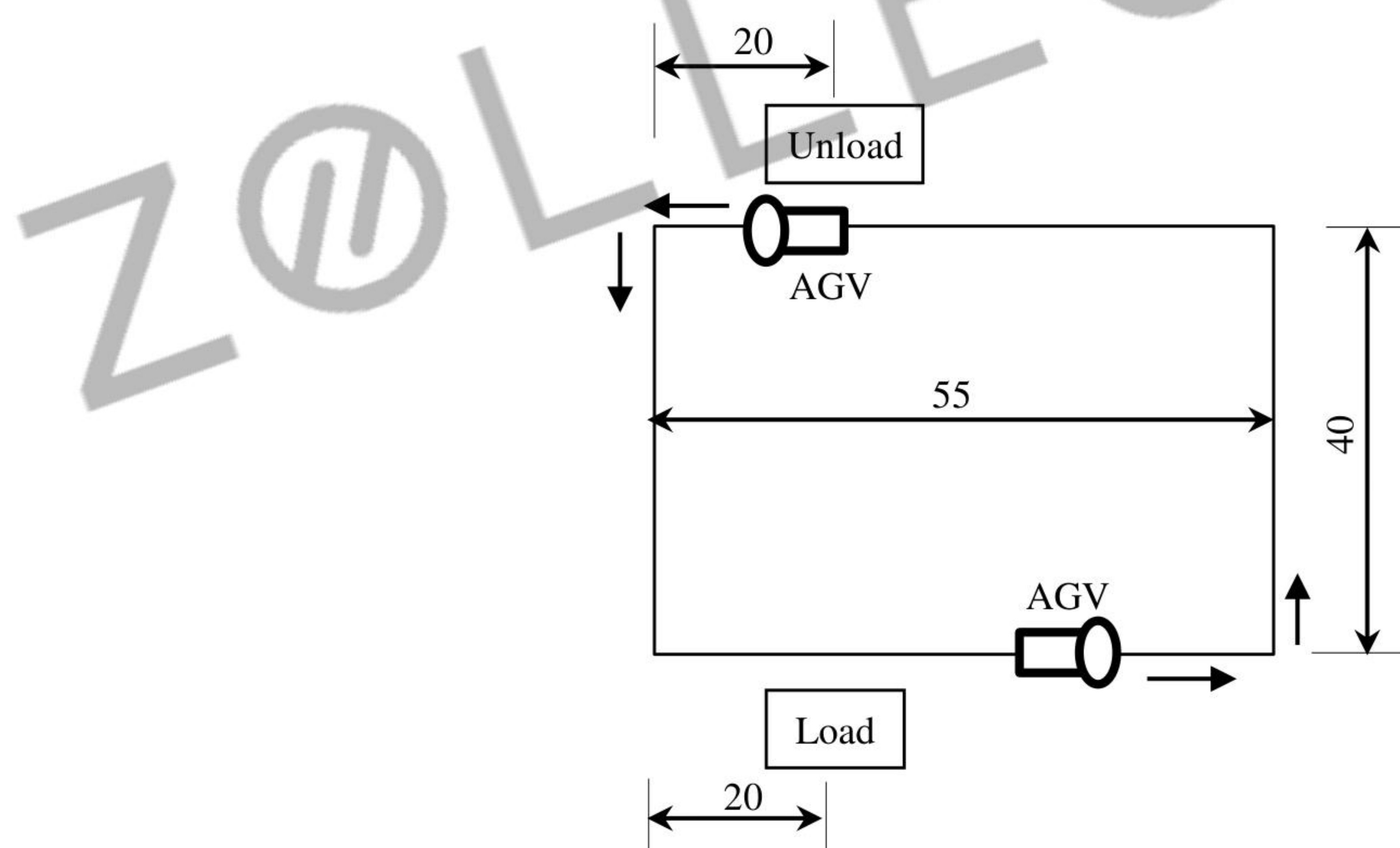
The variance (in days) of the critical path is _____ (round off to 2 decimal places)

Q.54 The sales data of a product for 5 years are

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

Assume the forecast for the year 2014 as 260 units. Using an exponential smoothing method with smoothing constant $\alpha = 0.5$, the sales forecast (units) for the year 2019, is _____

Q.55 The layout for an AGV system is shown in figure. The loading time is 0.5 minutes and the unloading time is also 0.5 minutes. All distances are in meters.



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

END OF THE QUESTION PAPER