GATE - ME - 2020 - 53 - 65

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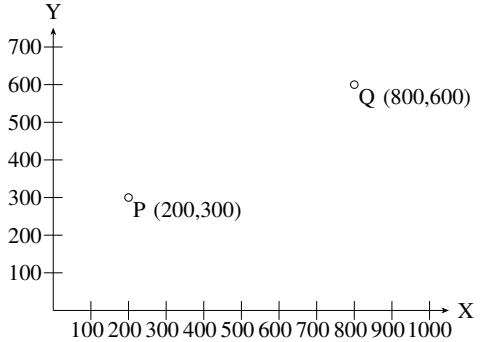
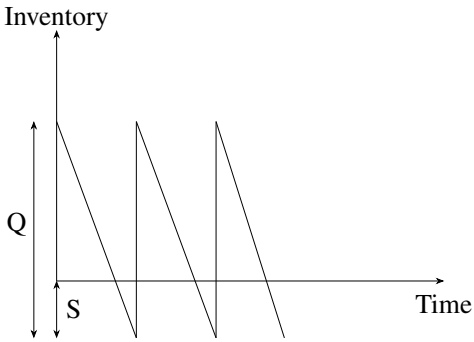
1) A cylindrical bar with 200 mm diameter is being turned with a tool having geometry $0^\circ - 9^\circ - 7^\circ - 8^\circ - 15^\circ - 30^\circ - 0.05$ inch (Coordinate system, ASA) resulting in a cutting force F_{c1}. If the tool geometry is changed to $0^\circ - 9^\circ - 7^\circ - 8^\circ - 15^\circ - 0^\circ - 0.05$ inch (Coordinate system, ASA) and all other parameters remain unchanged, the cutting force changes to F_{c2}. Specific cutting energy (in J/mm^3) is $U_c = U_0 t_1^{-0.4}$, where U_0 is the specific energy coefficient, and t_1 is the uncut thickness in mm. The value of percentage change in cutting force F_{c2} i.e. $\left(\frac{F_{c2}-F_{c1}}{F_{c1}}\right)\times 100$, is ..... (round off to one decimal place). (GATE ME 2020)
2) There are two identical shaping machines S_1 and S_2. In machine S_2, the width of the workpiece is increased by 10% and the feed is decreased by 10%, with respect to that of S_1. If all other conditions remain the same then the ratio of total time per pass in S_1 and S_2 will be ..... (round off to one decimal place). (GATE ME 2020)
3) Bars of 250 mm length and 25 mm diameter are to be turned on a lathe with a feed of 0.2 mm/rev. Each regrinding of the tool costs Rs. 20. The time required for each tool change is 1 min. Tool life equation is given as $VT^{0.2} = 24$ (where cutting speed V is in m/min and tool life T is in min). The optimum tool cost per piece for maximum production rate is Rs. ..... (round off to 2 decimal places). (GATE ME 2020)
4) A point 'P' on a CNC controlled XY-stage is moved to another point 'Q' using the coordinate system shown in the figure below and rapid positioning command (G00).

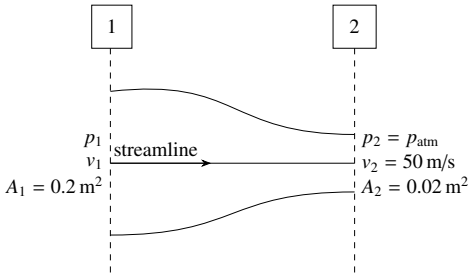


A pair of stepping motors with maximum speed of 800 rpm, controlling both the X and Y motion of the stage, are directly coupled to a pair of lead screws, each with a uniform pitch of 0.5 mm. The time needed to position the point 'P' to the point 'Q' is ..... minutes (round off to 2 decimal places). (GATE ME 2020)
5) For a single item inventory system, the demand is continuous, which is 10000 per year. The replenishment is instantaneous and backorders (S units) per cycle are allowed as shown in the figure.



As soon as the quantity (Q units) ordered from the supplier is received, the backordered quantity is issued to the customers. The ordering cost is Rs. 300 per order. The carrying cost is Rs. 4 per unit per year. The cost of backordering is Rs. 25 per unit per year. Based on the total cost minimization criteria, the maximum inventory reached in the system is ..... (round off to nearest integer). (GATE ME 2020)

6) Consider a flow through a nozzle, as shown in the figure below.



The air flow is steady, incompressible and inviscid. The density of air is $1.23\,\text{kg/m}^3$. The pressure difference, $(p_1 - p_{\text{atm}})$ is _____ kPa (round off to 2 decimal places). (GATE ME 2020)

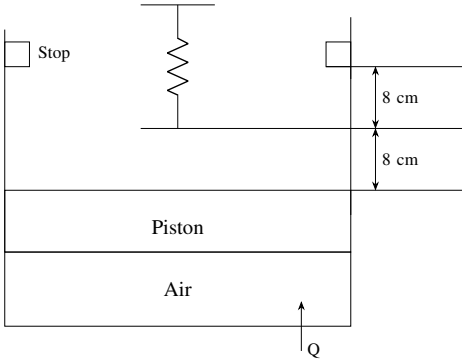
7) Water (density $1000\,\text{kg/m}^3$) flows through an inclined pipe of uniform diameter. The velocity, pressure and elevation at section A are $V_A = 3.2\,\text{m/s}$, $p_A = 186\,\text{kPa}$ and $z_A = 24.5\,\text{m}$, respectively, and those at section B are $V_B = 3.2\,\text{m/s}$, $p_B = 260\,\text{kPa}$ and $z_B = 9.1\,\text{m}$, respectively. If acceleration due to gravity is $10\,\text{m/s}^2$ then the head lost due to friction is _____ m (round off to one decimal place). (GATE ME 2020)

8) The spectral distribution of radiation from a black body at $T_1 = 3000\,\text{K}$ has a maximum at wavelength λ_{max}. The body cools down to a temperature T_2. If the wavelength corresponding to the maximum of the spectral distribution at T_2 is 1.2 times of the original wavelength λ_{max}, then the temperature T_2 is _____ K (round off to the nearest integer). (GATE ME 2020)

9) Water flows through a tube of 3 cm internal diameter and length 20 m. The outside surface of the tube is heated electrically so that it is subjected to uniform heat flux circumferentially and axially. The mean inlet and exit temperatures of the water are 10°C and 70°C, respectively. The mass flow rate of the water is 720 kg/h. Disregard

the thermal resistance of the tube wall. The internal heat transfer coefficient is $1697\,W/m^2 \cdot K$. Take specific heat C_p of water as $4.179\,kJ/kg \cdot K$. The inner surface temperature at the exit section of the tube is _____ °C (round off to one decimal place). (GATE ME 2020)

10) Air is contained in a frictionless piston-cylinder arrangement as shown in the figure.



The atmospheric pressure is 100 kPa and the initial pressure of air in the cylinder is 105 kPa. The area of piston is $300\,cm^2$. Heat is now added and the piston moves slowly from its initial position until it reaches the stops. The spring constant of the linear spring is 12.5 N/mm. Considering the air inside the cylinder as the system, the work interaction is ..... J (round off to the nearest integer). (GATE ME 2020)

11) Moist air at 105 kPa, 30°C and 80% relative humidity flows over a cooling coil in an insulated air-conditioning duct. Saturated air exits the duct at 100 kPa and 15°C. The saturation pressures of water at 30°C and 15°C are 4.24 kPa and 1.7 kPa respectively. Molecular weight of water is 18 g/mol and that of air is 28.94 g/mol. The mass of water condensing out from the duct is ..... g/kg of dry air (round off to the nearest integer). (GATE ME 2020)

12) In a steam power plant, superheated steam at 10 MPa and 500°C, is expanded isentropically in a turbine until it becomes a saturated vapour. It is then reheated at constant pressure to 500°C. The steam is next expanded isentropically in another turbine until it reaches the condenser pressure of 20 kPa. Relevant properties of steam are given in the following two tables. The work done by both the turbines together is ..... kJ/kg (round off to the nearest integer). (GATE ME 2020)

Superheated Steam Table			
Pressure, p (MPa)	Temperature, T (°C)	Enthalpy, h (kJ/kg)	Entropy, s (kJ/kg.K)
10	500	3373.6	6.5965
1	500	3478.4	7.7621

13) Keeping all other parameters identical, the Compression Ratio (CR) of an air standard diesel engine is increased from 15 to 21. Take ratio of specific heats = 1.3 and cut-off ratio of the cycle $r_c = 2$.
The difference between the new and the old efficieny values, in percentage

Saturated Steam Table					
Pressure, p	Sat. Temp., T_{sat} (°C)	Enthalpy, h (kJ/kg)		Entropy, s (kJ/kg.K)	
		h_f	h_g	s_f	s_g
1 MPa	179.91	762.9	2778.1	2.1386	6.5965
20 kPa	60.06	251.38	2609.7	0.8319	7.9085

$(\eta_{new}|_{CR=21}) - (\eta_{old}|_{CR=15})$ = ... % (round off to one decimal places). (GATE ME 2020)