MECHANICAL ENGINEERING Paper I

Time Allowed: Three Hours **Maximum Marks: 300**

Question Paper Specific Instructions

***Please read each of the following instructions carefully before attempting questions*:**

*There are **EIGHT** questions divided in **TWO** Sections.*
*Candidate has to attempt **FIVE** questions in all.*
*Question Nos. **1** and **5** are **compulsory** and out of the remaining, any **THREE** are to be attempted choosing at least **ONE** from each Section.*
The number of marks carried by a question/part is indicated against it.
Wherever any assumptions are made for answering a question, they must be clearly indicated.
Diagrams/Figures, wherever required, shall be drawn in the space provided for answering the question itself.
Unless otherwise mentioned, symbols and notations have their usual standard meanings.
Psychrometric Chart is given in Page No. 7.
Attempts of questions shall be counted in sequential order. Unless struck off, attempt of a question shall be counted even if attempted partly.
Any page or portion of the page left blank in the Question-cum-Answer Booklet must be clearly struck off.
*Answers must be written in **ENGLISH** only.*

SECTION—A

Q1. (a) What is Laminar sublayer? For the velocity profiles given below, state whether the boundary layer has separated or is on the verge of separation or will remain attached with the surface: 12

(i) $\frac{u}{U} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$

(ii) $\frac{u}{U} = -2\left(\frac{y}{\delta}\right) + \left(\frac{y}{\delta}\right)^2$

(iii) $\frac{u}{U} = \frac{3}{2}\left(\frac{y}{\delta}\right)^2 + \frac{1}{2}\left(\frac{y}{\delta}\right)^3$

The symbols have their usual meaning.

(b) A heat engine receives reversibly 420 kJ/cycle of heat from a source at 327°C and rejects heat reversibly to a sink at 27°C. There are no other heat transfers. For each of the three hypothetical amounts of heat rejected in (i), (ii) and (iii) below, compute the cyclic integral of $\oint \frac{dQ}{T}$. From these results, show which case is irreversible, which is reversible and which is impossible: 12

(i) 210 kJ/cycle rejected
(ii) 105 kJ/cycle rejected
(iii) 315 kJ/cycle rejected

(c) Deduce an expression for the shape factor of a hemispherical cavity within itself. 12

(d) What is negative slip in a reciprocating pump?
The suction lift is 4 m, length of suction pipe 6.5 m, diameter of suction pipe 100 mm, diameter of piston 150 mm and length of stroke is 0.45 m. Assume

simple harmonic motion, atmospheric pressure head as 10.3 m of water and separation occurs at 26 m of water absolute.
Determine the maximum speed at which a double acting reciprocating pump can be operated if fitted with an air vessel on the suction side close to the pump. Darcy's $f = 0.024$. 12

(e) Flue gas analysis using Orsat apparatus provides the following data for combustion of an unknown hydrocarbon :

$$CO_2 = 12.0\%,\ CO = 0.8\%,\ O_2 = 3.l\%,\ N_2 = 84.1\%$$

Determine air-fuel ratio, fuel composition on mass basis, stoichiometric air-fuel ratio and percentage of excess air. 12

Q2. (a) A four cylinder, four stroke square engine having a bore of 100 mm operating at 4000 rpm has a compression ratio 7.
If the relative efficiency is 60% when the specific fuel consumption is 250 gm/kWh, estimate (i) how many times the spark will trigger in one minute per cyclinder, (ii) number of thermodynamic cycles per cylinder per second, (iii) calorific value of the fuel, and (iv) corresponding fuel consumption in kg/hr, given that the mean effective pressure is 8.5 bar. 20

(b) An infinite slab of thickness "L" (m) is having thermal conductivity "K" (W/mK). It is generating heat at a uniform rate of "$\dot{q}$ ". One of the sides of the slab is perfectly insulated and the other side is maintained at a constant temperature of "T_w" (°C). Deduce an expression for the temperature distribution within the slab. Also find out the position of maximum temperature in the slab. 20

(c) A solid cylinder of 15 cm diameter and 60 cm length, consists of two parts made of different materials. The first part at base is 1.2 cm long and has specific gravity of 5.0. The other part of the cylinder is made of material having specific gravity of 0.6. Determine whether it can float vertically or not in water. 20

Q3. (a) An all glass body air-conditioned bus is having height of 3 m, width of 3 m and length of 10 m. Inside surfaces of the glass are maintained at 20°C. The bus is moving at a speed of 60 kmph. Atmospheric temperature is 34°C. Neglecting the conduction resistance of the glass and assuming walls and roof are perfectly flat, find the following: 20

(i) Heat gained by the bus from the roof and side walls. (Neglect Laminar Region).

(ii) Capacity of Air Conditioner Unit required in tonnes of refrigeration (TR) to remove the heat gained as given in (i).

(iii) Power required to run the air-conditioning unit if the COP is 4.

Take the properties of the air as given below:

Density = 1.1774 kg/m^3.

Kinematic viscosity = 1.569×10^{-5} m^2/s.

Thermal conductivity = 0.02624 W/mK

Pr = 0.708

For turbulent flow $Nu_L = 0.036\,Re_L^{0.8}\,Pr^{0.33}$.

(b) (i) (I) For a given thermodynamic system while considering control volume approach, what is the significance of flow work? Is flow work a path function or point function? 4

(II) With a neat sketch apply steady flow energy equation to a system handling incompressible fluid (like pump) and a system handling compressible fluid flow (like compressor). Draw important inferences from the steady flow energy equations of pump and compressor. 6

(ii) (I) Show that COP of a heat pump is greater than COP of a refrigerator. 4

(II) A housewife keeps the door of a refrigerator open in order to beat the heat of summer by closing the door and window of a kitchen. However the cooling effect wears out with the passage of time and she feels uncomfortable with the rise of temperature. Assume the room plaster is well insulated with no heat exchange to the surroundings. How will you evaluate this case in the context of first law of thermodynamics? 6

(c) A vertical cylindrical rod of 1 m length is maintained at a temperature of 120°C. Diameter of the rod is 5 cm. It is exposed to a very large room having surrounding air and wall temperature at 34°C. It has surface emissivity of 0.7.

Find the following: 20

(i) Heat lost by the rod by convection.

(ii) Heat lost by the rod by radiation.

(iii) Total heat loss by the rod.

(iv) Percentage of convection and radiation heat loss.

(v) Is it correct to neglect the radiation heat loss for this situation?

Take the property values of air as given below:

Density = 0.998 kg/m^3.

Kinematic viscosity = 2.076×10^{-5} m^2/s.

Thermal conductivity = 0.03 W/mK.

Pr = 0.697

Stefan's Constant = 5.67×10^{-8} m^{2}K^4.

Use correlation

$$Nu_L = 0.1[Gr_L\ Pr]^{0.33}$$

Neglect heat loss from the ends.

Q4. (a) A circular pipe of length 500 m and diameter 400 mm is connected with a reservoir at one end and to the atmosphere at the other end. The pipe has rounded entrance (K = 0.15), sudden contraction to 400 mm (K = 0.25), sharp bend (K = 0.18), gate valve full open (K = 8) and sudden expansion to 500 mm pipe. Assuming pipe friction loss coefficient as 0.012, determine discharge for head of 50 m at entrance. K is the head loss coefficient. 20

(b) In a double pipe, parallel flow heat exchanger, hot fluid enters at 120°C and leaves at 80°C. Cold fluid enters at 20°C and leaves at 50°C. If inlet temperatures, overall heat transfer coefficient and flow rate of the fluids remain same, find the exit temperatures of the fluids if counter flow arrangement is used. Use effectiveness method.

Effectiveness of parallel flow heat exchanger = $\dfrac{1-e^{[-N(1-C)]}}{1+C}$

Effectiveness of counter flow heat exchanger = $\dfrac{1-e^{[-N(1-C)]}}{1-Ce^{[-N(1-C)]}}$

where N = NTU, $C = C_{min}/C_{max}$. 20

(c) Explain variation in specific heat of gases and its influence on engine performance. Also explain how actual cycle differs from air fuel cycle. Explain exhaust blow-down loss for SI engine. 20

SECTION—B

Q5. (a) A compound parabolic collector, 2 m long (L), has an acceptance angle ($2\theta_a$) of 30°. The absorber surface of the collector is flat and has a width (b) of 20 cm. Calculate the concentration ratio (C), the aperture width (W), the height (H), and the surface area (A_{con}) of the concentrator. 12

(b) In the context of engine components, answer the following:

(i) Why are there multiple intake and multiple exhaust valves nowadays in modern engines? How will you identify inlet valve from exhaust valve through visual inspection? 6

(ii) Why are pistons made tapered? How will you identify a piston of a two-stroke engine from the piston of a four-stroke engine through visual inspection assuming same engine capacity? 6

(c) In an air-conditioning unit, 10 m^3/min of air from atmospheric condition of DBT 40°C and Relative humidity 70% is adiabatically mixed with 90 m^3/min of recirculation air coming from the air-conditioned chamber. Condition of the recirculation air is DBT 25°C and WBT 20°C. Find the Enthalpy, Specific humidity, Relative humidity and WBT of the air after mixing.

Also draw the process in a skeleton Psychrometric chart. [Psychrometric chart is attached.] 12

(d) With the help of diagram, show the placing of evaporator, superheater, reheater and economiser in the boiler. Also justify the placement at specific location. 12

(e) Explain the effect of the following on the COP of Vapour Compression refrigeration cycle with suitable P-h diagram: 12

(i) Subcooling of the liquid in condenser.

(ii) Decrease of Evaporator temperature,

(iii) Wet Compression.

Q6. (a) Show that a Pelton turbine with coefficient of velocity C_v and blade friction coefficient K can have a maximum hydraulic efficiency:

$$(\eta_H)_{max} = \frac{1}{2} C_v^2 (1 + K \cos \beta')$$

where β' = (180 – blade angle).

A double overhang Pelton wheel unit is coupled to a generator producing 30,000 kW under an effective head of 300 m at the base of the nozzle. Find the size of the jet, mean diameter of runner, synchronous speed and specific speed of each wheel. Assume generator efficiency as 93%, overall efficiency of turbine as 85%, coefficient of nozzle velocity as 0.97, speed ratio as 0.46, frequency of generator as 50 cycles per second, pair of poles as 16 and the jet ratio as 12.

Also take ρ_{water} = 1000 kg/m^3.

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(b) (i) What are the major sources of air leakage in the condenser of a power plant? Write the effect of pressure of air on the performance of the plant.

Also discuss working of air ejector. 8

(ii) In a typical power plant, steam at 35°C goes to the condenser. Steam flow is 650 T/hr. Moisture in steam at inlet of condenser is 12%. Condenser pressure is maintained at 0.075 bar. Cooling water enters at 23°C and leaves condenser at 33°C. Find rate of cooling water flow and rate of air leak in the condenser. Take the following data at 0.075 bar: 12

h_f, specific enthalpy of saturated water = 146.7 kJ/kg

h_{fg}, specific enthalpy of conversion from saturated liquid to dry vapour = 2418.6 kJ/kg

v_f, specific volume of saturated water = 0.001006 m^3/kg

v_{fg}, specific volume of conversion from saturated liquid to dry vapour = 25.22 m^3/kg

Specific heat of water = 4.187 kJ/kg K

R = 0.287 kJ/kg K

(c) What do you understand by biomass gasification? How are gasifiers classified? Describe with a schematic diagram the working of a downdraft gasifier. 20

Q7. (a) What is meant by volumetric efficiency of a reciprocating compressor? How is it affected by

(i) Speed of the compressor,

(ii) Throttling across valves, and

(iii) Delivery pressure?

It is desired to compress air at 1 bar and 25°C and deliver it at 160 bar using multi-stage compression and intercoolers. The maximum temperature during compression must not exceed 125°C and cooling in the intercooler is done so as not to drop the temperature below 30°C. The law of compression followed is $PV^{1.25}$ = constant for all stages.

Calculate: 20

(i) Number of stages required,

(ii) Work input per kg of air, and

(iii) Heat rejected in the intercoolers.

Take R = 0.287 kJ/kg K, C_v = 0.71 kJ/kg K

(b) Explain why ideal regenerative feed water heating is not used in practice. Derive expression of optimum regeneration to get maximum efficiency with one regenerative feed water heater. 20

(c) (i) What is the consideration while deciding number of blades for a horizontal axis wind turbine? State the significance of optimal tip-speed ratio and comment what will happen if the tip-speed ratio is very high or very low. 10

(ii) A 3-bladed rotor of horizontal axis wind turbine having blade length of 40 m is installed at a location where free wind velocity of 20 m/sec is available. What shall be the ideal rotor speed that can be maintained for optimal energy extraction? 10

Q8. (a) Prove that the efficiency corresponding to the maximum work done in a Brayton cycle is given by the relation

$$\eta_{w,\max} = 1 - \frac{1}{\sqrt{t}}$$

where t is the ratio of the maximum and minimum temperatures of the cycle. An ideal open-cycle gas turbine plant using air operates in an overall pressure ratio of 4 and between temperature limits of 300 K and 1200 K. Assuming the constant value of specific heat C_p = 1 kJ/kg K and C_v = 0.717 kJ/kg K, evaluate the specific work output and thermal efficiency for:

(i) basic cycle with regenerator (heat exchanger), and

(ii) basic cycle with regenerator (heat exchanger) and two-stage intercooled compressor. Assume optimum stage pressure ratios, perfect intercooling and perfect regeneration.

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(b) The velocity of steam entering in a simple impulse turbine is 800 m/s and nozzle angle is 22°. The mean peripheral velocity of blades is 300 m/s and blades are symmetrical. Calculate the following for steam flow of 2 kg/sec:

(i) Blade angles for entry without shock.

(ii) Tangential thrust.

(iii) Diagram power.

(iv) Diagram efficiency.

(v) Axial thrust.

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(c) (i) Why are solar PV panels placed inclined due south in Indian context? What is the basis of deciding the slope of such solar panels?

6

(ii) A solar PV panel feeds a dc motor to produce 1 hp of power at shaft output. The motor efficiency is 80%. Each module has multicrystalline silicon solar cells arranged in 9 × 4 matrix. The cell is 125 mm × 125 mm and cell efficiency is 15%. Calculate the number of modules requirement in the array. Assume global radiations incident normally to the panel as 1000 W/m^2.

14

MECHANICAL ENGINEERING Paper II

Time Allowed: Three Hours **Maximum Marks: 300**

Question Paper Specific Instructions

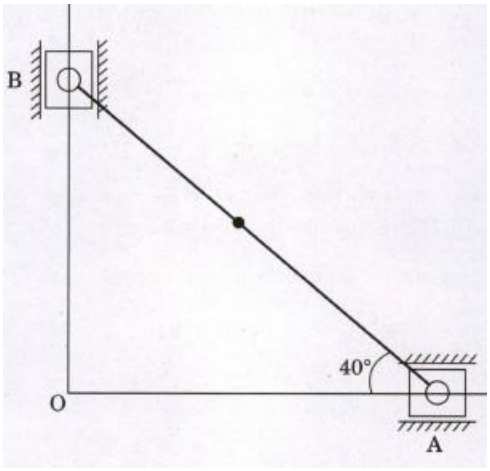
***Please read each of the following instructions carefully before attempting questions*:**

*There are **EIGHT** questions divided in **TWO** sections.*
*Candidate has to attempt **FIVE** questions in all.*
*Questions No. **1** and **5** are compulsory and out of the remaining, **THREE** are to be attempted choosing at least **ONE** question from each section.*
The number of marks carried by a question/part is indicated against it.
Answers must be written in the medium authorized in the Admission Certificate which must be stated clearly on the cover of this Question-cum-Answer (QCA) Booklet in the space provided. No marks will be given for answers written in a medium other than the authorized one.
Assume suitable data, if considered necessary and indicate the same clearly.
Unless otherwise mentioned, symbols and notations carry their usual standard meanings.
Attempts of questions shall be counted in sequential order. Unless struck off, attempt of a question shall be counted even if attempted partly.
Any page or portion of the page left blank in the Question-cum-Answer Booklet must be clearly struck off
*Answers must be written in **ENGLISH** only.*

SECTION A

Q1. (a) A light wooden log of length L is floating on water with a concentrated load W acting at the mid-point. Write the equations and draw the diagram for shearing force and bending moment. 12

(b) The slider A, of an elliptical trammel shown in the figure moves towards O with a velocity of 3 m/s at the instant when AB makes an angle of 40° with the horizontal. Determine the velocity of the mid-point of the link AB at this instant.



12

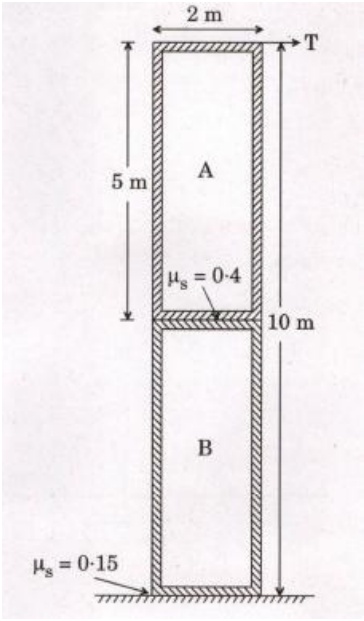
(c) State and prove the law of gearing. 12

(d) Explain with suitable illustration the S-N curve of a ferrous material and briefly discuss its significance in the design of machine elements. 12

(e) A shaft made of mild steel is required to transmit 100 kW at 300 rpm. The supported length of the shaft is 3 metres. It carries two pulleys, each weighing 1500 N supported at a distance of 1 metre from the ends respectively. Assuming the safe value of stress to be 60 N/mm^2, determine the diameter of the shaft.

12

Q2. (a) A 500 N crate A rests on a 1000 N crate B. The centres of gravity of the crates are at the geometric centres. The coefficients of static friction between contact surfaces are shown in the diagram. The force T is increased from zero. What is the first action to occur?



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(b) A single cylinder, single acting, 4-stroke engine develops 20 kW at 250 rpm. For the sake of simplicity, the turning moment curve is represented by two isosceles triangles during compression and expansion stroke. The turning moment can be assumed zero for suction and exhaust stroke. The work done by the gases is 3 times more than the work done on the gases. If the flywheel has a mass of 1500 kg and has a radius of gyration of 0.6 m, find the coefficient of fluctuation of speed.

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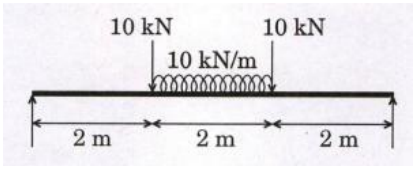
(c) A single-plate clutch is used to rotate a machine from a shaft rotating at a uniform speed of 300 rpm. Both sides of the clutch are effective, friction lining is of 140 mm inner diameter and 220 mm outer diameter, respectively. The coefficient of friction between friction lining and flywheel surface is 0.28. Assuming uniform wear theory for clutch and maximum intensity of pressure 0.1 MPa, determine the time required to attain full speed by the machine if moment of inertia of the rotating parts is 7.2 kg-m^2. How much energy has been lost during slipping of the clutch?

20

Q3. (a) A beam is loaded as shown in the figure. If $E = 200 \times 10^6$ kN/m^2 and $I = 10^{-4}$ m^4, determine

(i) slope at the ends, and

(ii) maximum deflection of the beam.



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(b) A shaft rotates in two bearings *A* and *B*, 1.8 m apart and projects 0.45 m beyond *A* and *B*. At the extreme ends of the shaft, two pulleys of masses 20 kg and 48 kg are attached with eccentricity of 12.5 mm and 15.5 mm respectively. In the middle of the bearings, another pulley of mass 50 kg is attached with an eccentricity of 15.5 mm.

If the three pulleys have been arranged so as to obtain static balance, determine the dynamic forces produced on the bearings when shaft speed is 300 rpm.

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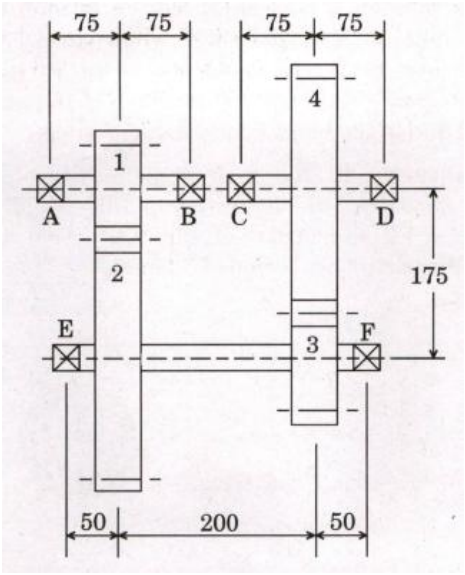
(c) The layout of a two-stage gear box is shown in the figure.



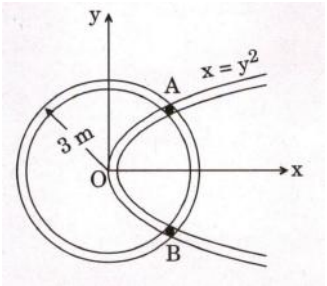
The number of teeth on the gears are as follows:

$$z_1 = 20 \qquad z_2 = 50 \qquad z_3 = 20 \qquad z_4 = 50$$

Pinion 1 rotates at 1440 rpm in anti-clockwise direction when observed from the left side and transmits 10 kW power to the gear train. The pressure angle is 20°. Draw a free body diagram of the gear tooth forces and determine the reactions at bearings *E* and *F*.

20

Q4. (a) Particles *A* and *B* are confined to always be in a circular groove of radius 3 m. At the same time, these particles must also be in a slot that has the shape of a parabola. The slot is shown at time $t = 0$ with equation $x = y^2$. If the slot moves to the right at a constant speed of 1.5 m/s, what are the speed and rate of change of speed of the particles towards each other at $t = 1$ s?



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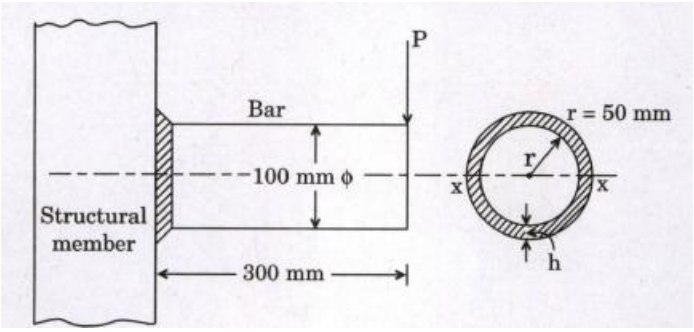
(b) A uniform disc of radius of gyration 60 mm and a mass of 4 kg is mounted

centrally on a horizontal axle of 80 mm length between the bearings. It spins at 800 rpm CCW when viewed from the right side bearing. The axle precesses about the vertical axis at 50 rpm in the clockwise direction when viewed from the top. Determine the reaction at each bearing due to the mass and gyroscopic effect.

20

(c) A solid circular bar of 100 mm diameter is welded to a structural member, as shown in the figure, by a fillet weld all round the bar. Determine the leg dimension of the fillet weld if P = 16 kN and permissible shear stress in weld is 90 N/mm^2.



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SECTION B

Q5. (a) A slab of aluminium of dimensions 25 cm × 20 cm × 5 cm is to be cast along with a side cylindrical riser. The riser is not insulated on any surface. If the volume shrinkage of aluminium during solidification is 5%, find

(i) the relationship between diameter and height of cylindrical riser for longest solidification time.

(ii) the minimum volume of riser required to compensate the shrinkage volume of casting. (Assume volume of riser = 3 × shrinkage volume of casting)

12

(b) To minimize the total processing time, arrange the sequence of operations of the jobs on the following five machines using Johnson's rule. The processing times (in minutes) of different jobs on individual machines are given below. Also find the total idle time on each machine.

12

Jobs	M/C 1	M/C 2	M/C 3	M/C 4	M/C 5
A	10	8	5	6	12
B	9	9	7	8	13
C	8	7	8	9	11
D	11	6	6	5	9

(c) What are the basic types of corrosion? Briefly describe any one of them.

12

(d) For an electronic component, the failure density function is defined as

$$f(t) = \begin{cases} 0.002e^{-0.0002t} & t \geq 0 \\ 0 & \text{otherwise.} \end{cases}$$

Determine the reliability of the component at 346.6 hours. Also determine the MTTF of the same component.

12

(e) What kind of motors are used in paper-feed and print-head-positioning mo-

tors in printers and plotters? Justify your answer(s) with reason. Show a schematic diagram of a two-phase permanent magnet stepper motor.

12

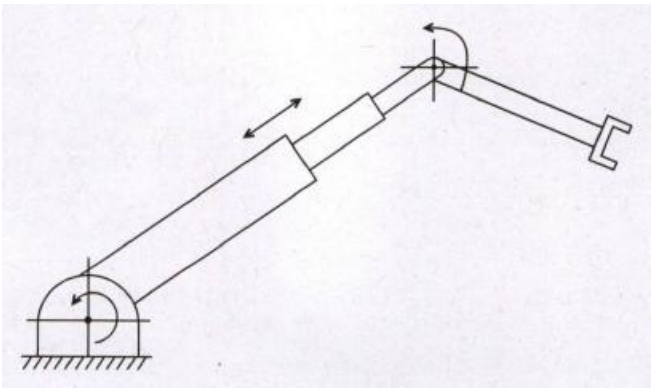
Q6. (a) During an orthogonal cutting of a metal, the following data were observed:
Chip thickness = 05 mm; width of cut = 3 mm; depth of cut = 0.3 mm; feed rate = 0.3 mm/rev; cutting force = 1200 N; feed thrust force = 300 N; cutting speed = 3 m/sec; rake angle = 10°.
Calculate:
(i) Shear force on the shear plane,
(ii) Coefficient of friction on chip-tool interface and friction angle, and
(iii) Percentage of total energy that goes into overcoming friction at chip-tool interface.

20

(b) (i) What are the different structures of ceramic compounds? Explain with neat sketches and examples. 12

(ii) The lattice constant of a metal with cubic lattice is 2.88 Å. The density of the metal is 7200 kg m^{-3}. Calculate the number of unit cells present in 1 kg of the metal. 8

(c) Consider the three-link planar manipulator of the figure given below. Derive the forward kinematic equations using the D-H Algorithm. Assume suitable link and joint parameters.



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where,

Link length – a_i Link twist – α_i Joint angle – θ_i
Joint displacement – d_i

Q7. (a) The production rates (units/day) of five workers on five different machines are given in the following table. To maximize the total production, assign the workers on specific machines using Hungarian method. Also find the total production per day.

20

		Production Units per day				
		M1	M2	M3	M4	M5
Workers	A	24	37	18	34	34
	B	18	37	20	31	42
	C	26	25	14	37	42
	D	22	25	26	40	50
	E	24	34	30	37	46

(b) In a roll forming process, a 20 mm thick plate is rolled to 16 mm in a four high mill. Determine the coefficient of friction considering it as maximum

possible reduction. The diameter of the roll is 480 mm. Also find neutral section, backward and forward slips and maximum pressure.
It is given that the value of σ_0 = 120 N/mm^2 for hot rolls of mild steel at about 1100°C.

20

(c) The kinematic parameters of a 3R planar articulated robot are given below:

link	a_i	α_i	d_i	θ_i
1	a_1	0	0	θ_1
2	a_2	0	0	θ_2
3	0	0	d_3	θ_3

Determine the kinematic model of the robot using D-H Algorithm and relation between adjacent frames.

20

Q8. (a) (i) There are three coordinate frames $o_1\ x_1\ y_1\ z_1$, $o_2\ x_2\ y_2\ z_2$ and $o_3\ x_3\ y_3\ z_3$, and relation between frames are given below:

$$^1R_2 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \frac{1}{2} & -\frac{\sqrt{3}}{2} \\ 0 & \frac{\sqrt{3}}{2} & \frac{1}{2} \end{bmatrix} \qquad ^1R_3 = \begin{bmatrix} 0 & 0 & -1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{bmatrix}$$

Find the matrix $^2R_3$ that relates frame {2} and {3}.

10

(ii) The homogeneous coordinates of a point are $_1P = [0\ 0\ 10\ 1]^T$. The coordinate frame is translated relative to the fixed {F} coordinate frame, by 6 units along x-axis and –2 units along y-axis. What is the homogeneous transformation matrix that represents the operation? What is the description of point P relative to the reference frame {F} following the translation?

10

(b) The demand for an item is observed as 24,000 units per year. The production capacity of the plant is 3,000 units per month. The item cost is Rs. 40 per unit and inventory carrying cost is 12% of the item cost per unit per year. The cost of one set-up is Rs. 480. The shortage cost of one unit is Rs. 240 per year. Supply of the item is non-instantaneous (gradual).
Determine the economic order quantity, optimal number of shortages, production line required for each cycle and the number of set-ups in a year.

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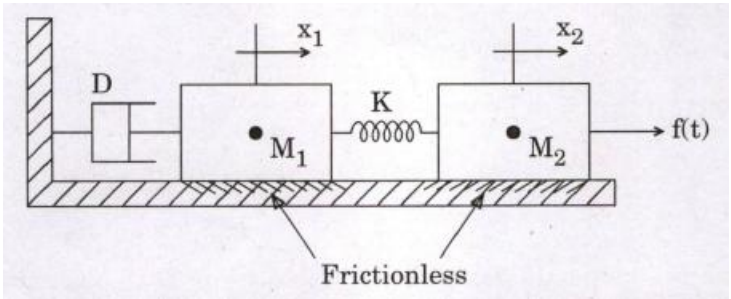
(c)



Find the state equations in matrix form for the translational mechanical system as shown above. Assume zero initial conditions, where

M_1 = Mass of block 1
M_2 = Mass of block 2
K = Spring stiffness constant
D = Coefficient of viscous friction
x_1 = Displacement of block 1
x_2 = Displacement of block 2

20