Q. No. ME - 301 / 117

B. Tech./Odd
2017-18/Reg

2017-18

SOLID MECHANICS

ME - 301

Full Marks : 70 Time : Three Hours

All are of equal marks.

Section - A

Answer *all* questions.

1. (i) The bulk modulus of a material having E=200GPa and G = 80GPa is

   (a) 233.3 GPa

   (b) 133.3 GPa

   (c) 250 GPa

   (d) 160 GPa

   (ii) In case of biaxial stresses, the maximum value of shear stress is

   (a) difference of normal stresses

   (b) half the difference of normal stresses

   (c) sum of normal stresses

   (d) half of sum of normal stresses

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(iii) In a transversely loaded beam, the maximum tensile stress in a rectangular section is at the

(a) top edge

(b) bottom edge

(c) neutral axis

(d) none of the above

(iv) Modulus of toughness is the area of the stress-strain diagram upto

(a) Rupture point

(b) Yield point

(c) Proportionality Limit

(d) None of these

(v) Maximum bending moment in a simply-supported beam of length 'L' carrying a uniformly distributed load 'w' is

(a) $\frac{wL^2}{4}$

(b) $\frac{wL^2}{8}$

(c) $\frac{wL^3}{4}$

(d) $\frac{wL^2}{2}$

(vi) Ratio of maximum to average shear stress in a rectangular section is

(a) 1.2

(b) 1.5

(c) 2

(d) 2.5

(vii) Ratio of maximum deflection of a simply supported beam to cantilever beam with a uniformly distributed load 'w' and length 'L' is

(a) 2

(b) 5/48

(c) 48/5

(d) 1/3

(viii) The ratio of strength of a hollow shaft to that of a solid shaft subjected to torsion if both are of the same material and of the same outer diameters, the inner diameter of hollow shaft being half of the outer diameter is

(a) 15/16

(b) 16/15

(c) 7/8

(d) 8/7

(ix) A continuous beam has

(a) one support

(b) two supports

(c) more than two supports

(d) very long span

(x) The buckling load of a column for a given material depends upon

(a) Poisson's ratio and slenderness ratio

(b) Poisson's ratio and modulus of elasticity

(c) Slenderness ratio and cross sectional area

(d) Slenderness ratio and modulus of elasticity

Section - B

Answer any *three* questions.

2. (i) Derive the relation $2G(1+\upsilon)=3K(1-2\upsilon)=\frac{KG}{G+3K}$.

Notations have their usual meaning.

(ii) A tubular strut hinged at both ends has outer and inner diameters as 160 mm and 120 mm, respectively. Determine the crippling load, which gives the same value Euler's and Rankine's formulae. Also determine the length of the strut for which it is possible. Consider E = 80 GPa and Yield Stress = 550MPa, a = 1/1600.

3. A 8-m long cantilever beam carries two point loads, 5 kN at the free end and 10 kN at a distance of 2 m from the free end. Determine the deflection curve using non-negativity functions. Also, determine the deflection beneath the point loads. Given that E = 200 GPa and $I = 10^{10}$ mm^4.

4. A plane element in a body is subjected to a normal stress in the x-direction of 82.74 MPa, as well as a shearing stress of 27.58 MPa.

(i) Determine the normal and shearing stress intensities on a plane inclined at an angle of 30° to the normal stress.

(ii) Determine the maximum and minimum values of normal and shear stresses that may exist on inclined planes and directions of these stresses.

5. (i) State and proof Castigliano's theorem.

(ii) A structure is in the form of one quadrant at a thin circular ring of radius R. One end is clamped and other end is loaded by a vertical force 'P' (see Fig. 1). Determine the vertical and horizontal displacement of the free-end under the point of application of the force 'P'. Consider only strain energy in bending.

6. (i) Define shear centre and explain it with a suitable example.

(ii) Derive the shear stress distribution of an I-section beam of subjected a shear force of 15 kN as shown in Fig. 2 (all dimensions are in mm). Plot the distribution and calculate the maximum, minimum and average shearing stresses and their locations.

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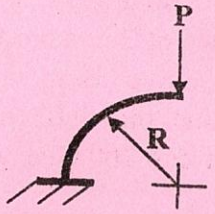

Fig. 1: A quarter circular ring.

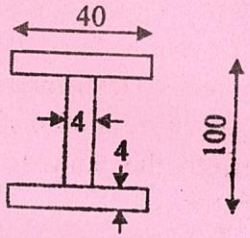

Fig. 2: An I-section beam.

Section - C

Answer any *three* questions.

7. A simply supported beam of length 4 m, carries the uniformly distributed load and a point load as shown in Fig.3. Draw the S.F and B.M. diagram for the beam. Also calculate the maximum bending moment.

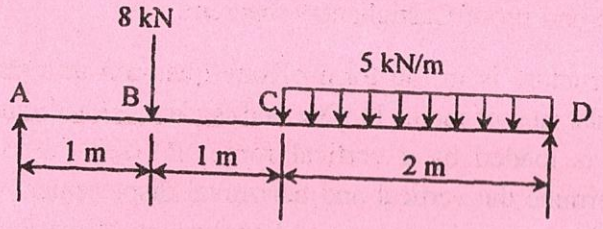

Fig.3

8. A railroad tie (Fig. 4) is 2.4 m long and has a 0.30 m×0.25 m rectangular cross section with the 0.30 m faces horizontal. The maximum loads transmitted to the tie by the rails are P = 250 kN each, and the ballast is assumed to exert a uniformly distributed reactive load on the bottom of the tie. Calculate the maximum bending stress in the tie if L = 1.425 m and a = 0.4875 m.

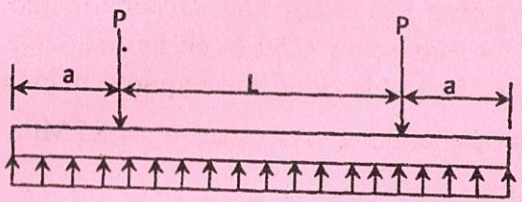

Fig. 4

9. The solid line shaft shown in Fig. 5 is made of steel, has diameter d = 40 mm and runs at 525 rpm. It is supported in bearings so placed that bending of the shaft will be negligible. A driving belt feeds 50 hp to the left hand pulley while 30 hp and 20 hp, respectively, are taken off by belts overrunning the middle and right hand pulleys. Compute the maximum shear stress τ induced in the shaft and the total angle of twist φ, Assume $G = 10^6$ kg/cm^2. Prove the formula used.

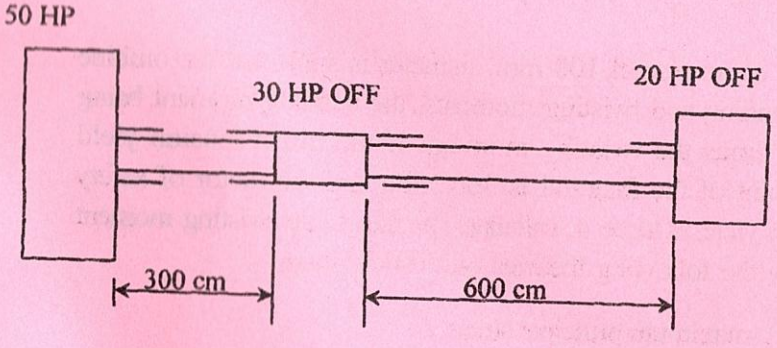

Fig.5

10. A steel shaft supporting in bearings A and B at its ends carries a pulley 0.60 m diameter at C as shown in Fig.6. Power is applied by a torque T at A and taken off through

a belt overrunning the pulley, the tensions in the two branches of the belt being 1250 N on the taut side and 250 N on the slack side. Find the required diameter d for the shaft if the working stresses are $\sigma_w = 85$ MPa and $\tau_w = 42.5$ MPa.

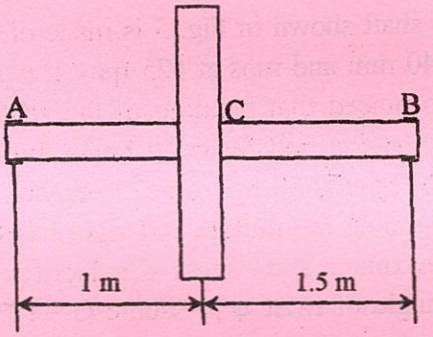

Fig. 6

11. A circular shaft 100 mm diameter is subjected to combine bending and twisting moments, the bending moment being 3 times the twisting moment. If the direct tension yield point of the material is 360 MPa and the factor of safety on yield is to be 4, calculate the allowable twisting moment by the following theories of elastic failure,

    (a) maximum principal stress,

    (b) maximum shearing stress,

    (c) maximum shear strain energy.

    State these Theories of failure.

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B. Tech./Odd
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THEORY OF MACHINES - I

ME - 302

Full Marks : 70 Time : Three Hours

The figures in the margin indicate full marks.

Answer any *two* questions from Group - A
and *three* questions from Group - B.

Group - A

1. (a) What is a quick return mechanism ? Explain it with a suitable diagram.

   (b) What is a kinematic pair ? What is the difference between a higher and a lower pair ?

   (c) State Grashof's law. Describe different inversions of four bar chain with necessary neat sketches.

   5+4+5=14

2. (a) What is Coriolis's component of acceleration of link mechanism ? — Derive the expression for the same.

   (b) In the steam engine mechanism shown in Fig.1, the crank AB rotates at 200 rpm. Find the velocities and accelerations of C, D, E, F, and P. The dimensions of the various links are: AB=12 cm, BC=48 cm, CD=18 cm, DE=36 cm, EF=12 cm, and FP=36 cm.

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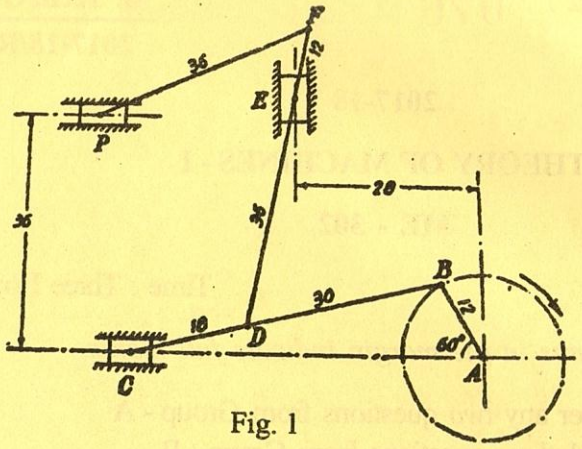

Fig. 1

4+10=14

3. (a) What is a gear train ? With the help of a sketch describe epicyclic gear train and point out its difference in operation from other gear trains.

(b) Fig. 2 shows an epicyclic gear train. Pinion A has 15 teeth and is rigidly fixed to the motor shaft. The wheel B has 20 teeth and gears with A, and also with annular fixed, wheel D. Pinion C has 15 teeth and is integral with B (C and B being a compound gear wheel). Gear C meshes with annular wheel E, which is keyed to machine shaft. The arm rotates about the same shaft on which A is fixed and carries compound wheel B and C. If the motor runs at 1000 rpm, find the speed of the machine shaft. Find the torque exerted on the machine shaft if the motor develops a torque of 100 Nm.

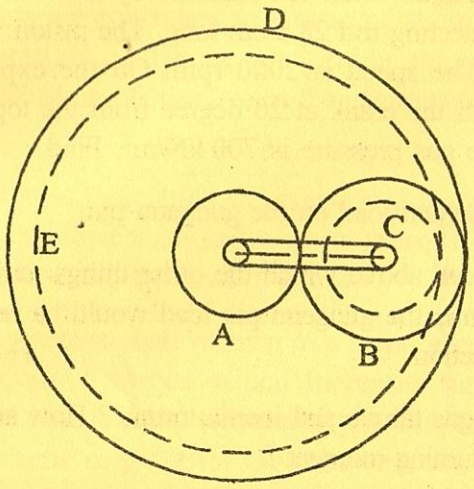

Fig.2

5+9=14

4. Answer the following questions :

(a) With neat sketch, describe Whitworth quick return mechanism. Why it is an inversion of slider crank mechanism ?

(b) In a simple engine mechanism derive the expression for angular acceleration of the connecting rod.

(c) Describe the operation of the speed gear of an automobile with a neat sketch. 14

Group - B

5. (a) What are primary and secondary inertia forces ? Secondary inertia force is a direct consequence of the finiteness of the connecting rod length — explain.

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(b) A petrol engine 11.25 cm diameter by 13.5 cm stroke has a connecting rod 28.5 cm long. The piston weight is 1 kg. The speed is 2000 rpm. On the explosion stroke with the crank at 20 degree from the top dead centre, the gas pressure is 700 kN/m^2. Find

(i) the resultant load on the gudgeon pin

(ii) the speed above which the other things remaining the same, the gudgeon pin load would be reversed in direction. 4+10=14

6. (a) What are gas torque and inertia torque ? How are they linked to turning moment ?

(b) For a horizontal reciprocating engine reciprocating mass = 125 kg, connecting rod mass = 100 kg, length of stroke = 20 cm, length of connecting rod between centres = 40 cm with location of its CG at 16 cm from big end, its radius of gyration about CG = 12 cm and engine speed = 750 rpm. Find the inertia torque on the crankshaft when crank angle is 30 degree from TDC. 4+10=14

7. (a) What is a turning moment diagram ? With the help of a turning moment diagram explain the function of a flywheel of a four stroke IC engine.

(b) The turning moment diagram for a petrol engine is drawn to the following scale : turning moment, 1 cm = 6000 Nm; crank angle, 1cm = 30 degrees. The turning moment diagram repeats itself at every half revolution of the engine and the areas above and below the mean turning moment line, taken in order are +2.95, – 6.85, +0.4, –3.4, +9.6 and –2.7 sq cm. The rotating

parts are equivalent to a mass of 40 kg at a radius of gyration of 1.8 m. Determine the coefficient of fluctuation of speed when the engine runs at 1500 rpm. 5+9=14

8. (a) Express fluctuation of energy in a fly wheel in terms of co-efficient of fluctuation of speed, mean speed and MOI of the flywheel.

(b) A machine shaft running at a mean speed of 250 rpm require a torque which increases uniformly from 700 Nm to 2800 Nm during the first half revolution, remains constant for the following one revolution. It then decreases uniformly to 700 Nm during the next half revolution and remains constant for one revolution, the cycle being then repeated.

If the driving torque applied to the shaft is constant and flywheel has a mass of 450 kg and a radius of gyration 60 cm, find

(i) The power necessary to drive the machine,

(ii) Percentage fluctuation of speed.

5+9=14

9. (a) With neat sketch derive the following expression of height of a Porter governor.

$$h = \frac{895}{N^2}\left(\frac{2mg + (Mg \pm f)(1+k)}{2mg}\right)m$$

and why Porter governor is much more sensitive than that of Watt governor ?

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(b) The arms of a Porter governor are 30 cm long. The upper arms are pivoted on the axis of rotation while the lower arms are attached to the sleeve at an offset of 4 cm from the axis. If ball mass is 10 kg and sleeve mass is 70 kg determine the equilibrium speed at the lowest position of the sleeve when the governor-radius is 20 cm. If, now, friction at the sleeve equivalent to 25 N is assumed, what will be the speed range of the governor for a lift of the sleeve of 6 cm ? 5+9=14

10. Answer any *three* of the following : 14

(a) What is piston effort ? Drive expression of Turning moment in term of piston effort.

(b) What is the function of a mechanical governor ? Though both the flywheel and the governor control speed fluctuation, their operations are different — explain.

(c) What do you mean by sensitiveness and hunting of a governor ?

(d) Explain the governor effort and power.

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Q. No. ME - 303 /

B. Tech./Odd

2017-18/Reg

2017-18

ENGINEERING THERMODYNAMICS

ME - 303

Full Marks : 70 Time : Three Hours

The figures in the margin indicate full marks.

Group - A

Answer any *two* questions.

Assume any suitable data if required.

1. (a) What do mean by "Thermodynamic Equilibrium", explain in detail.

   (b) Give the statement of "Zeroth law of Thermodynamics".

   (c) How can a closed system and its surroundings interact ? What is the effect of such interactions on the system ? Show with a sketch convention +ve and –ve work and heat interaction. 3+3+(2+2+2)=12

2. (a) Give the statement of 1st law of thermodynamics applied for a closed system taken through a cycle.

   (b) Define internal energy of a system from 1st law of thermodynamics and give the expression of non-flow energy equation. Prove that change of internal energy of a system is point function by considering a change of state and its return to the original state by a different path.

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(c) The rate of heat transfer to the surroundings from a person at rest is about 400 kJ/hour. Suppose that the ventilation system fails in an auditorium containing 1200 person, how much the internal energy of the auditorium increases during first 20 minutes after the ventilation system fails ?

(d) A tank containing a fluid is stirred by a suitable arrangement. The work input is 5090 kJ. The heat transfer from the tank is 1500 kJ. Considering the tank and the fluid as a single system determine the change in internal energy. 2+(1+1+3)+3+2=12

3. (a) Give "Plank's statement of second law of thermodynamics" and derive "Clausius statement" in the context of the former.

(b) State Carnot's theorem and prove it in the light of the second law of thermodynamics.

(c) A Carnot Engine absorbs 1000 kJ energy as heat from a reservoir at 500 K and rejects energy to a sink at 300 K. Determine the efficient of the engine and the energy rejected to the sink. (2+3)+(2+3)+2=12

Group - B

Answer Q. 4 (compulsory) and any *one* question from the rest.

Use Steam Table and Mollier Diagram to find out steam properties. Assume suitable data if necessary.

4. (a) Draw the Carnot cycle and Rankine cycle of steam on temperature-entropy plane and derive the expression of cycle efficiencies in terms of temperatures only. Also compare the two cycles.

(b) Draw the phase equilibrium diagram on Pressure-Volume, and Pressure-Temperature coordinates for a substance which expands in volume on melting at a temperature variation between (-) 50°C and 150°C.

(c) What is binary vapour cycle ? With necessary diagram explain the working principle of mercury-steam binary cycle. 5+3+4=12

5. (a) When is reheating of steam recommended in a steam power plant ? Draw the Rankine cycle with reheat on Temperature-Entropy plane and derive the expressions of turbine work, pump work, heat addition, heat rejection, and cycle efficiency in terms of enthalpy only. What is the optimum reheat pressure for achieving maximum cycle efficiency ?

(b) A steam power plant operates on an ideal reheat Rankine cycle between the pressure limits of 9 MPa and 10 kPa. The mass flow rate of steam through the cycle is 25 kg/s. Steam enters both stages of the turbine at 500°C. If the moisture content of the steam exiting the low-pressure turbine should not to exceed 10%, determine :

(i) the reheat pressure,

(ii) total rate of heat input in the boiler,

(iii) net work output, and

(iv) the thermal efficiency of the cycle. 6+6=12

6. (a) Draw the flow diagram, temperature-entropy diagram of regenerative Rankine cycle for superheated steam with single open-type feed water heater. Determine the

mass flow rate of the extracted steam, work done at turbine and pumps, heat addition and rejection, and plant efficiency.

(b) An ideal regenerative cycle operates with steam supplied at 30 bar, 400°C and a condenser pressure of 0.1 bar. For the cycle find the cycle efficiency. Also, calculate the amount of steam extracted and quality of steam at condenser inlet, if the point of extraction is at 5 bar pressure. Consider open type of feed water heater. 6+6=12

Group - C

Answer any *two* questions.

7. (a) Define air standard efficiency and explain its importance.

(b) Derive an expression of air standard efficiency for diesel cycle.

(c) The stroke and cylinder diameter of a diesel cycle are 175 mm and 150 mm respectively. If the clearance volume is 0.00035 m^3 and fuel injection takes place for 6 per cent of the stroke, determine the air standard efficiency of the engine. 3+4+4=11

8. (a) Explain briefly Brayton cycle and derive the expression for its air standard efficiency.

(b) In Brayton cycle prove that the pressure ratio for maximum work is a function of the limiting temperature ratio.

(c) Air enters the compressor of a gas turbine operating on Brayton cycle at 1 bar, 27°C. The pressure ratio

of the cycle is 6. Calculate the power developed of the cycle, and the exhaust gas temperature if the maximum temperature is limited to 1000 K. 3+4+4=11

9. (a) Define heat pump and refrigerator. Derive the expression of COP for the both.

(b) Briefly discuss the air refrigeration system working on reversed Brayton cycle and derive an expression for C.O.P.

(c) In a refrigeration plant working on Bell Coleman cycle, air is compressed to 6 bar. Initial condition of air before compression is 1 bar and 10°C. After compression air cooled upto 20°C in a cooler before expanding back to pressure of 1 bar. Determine; the theoretical COP of the plant and Net refrigerating effect. 3+4+4=11

Date: 09.01.18

Q. No. ME - 304 / 151

B. Tech./Odd
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FLUID MECHANICS - I

ME - 304

Full Marks : 70 Time : Three Hours

The figures in the margin indicate full marks.

Group - A

Answer Question No. 1 and any *one* from the rest.

1. (a) In equilibrium condition, derive the pressure difference due to surface tension for a curved liquid interface. 2½

(b) A spherical soap bubble of diameter d_1 coalesces with another bubble of diameter d_2 to form a single bubble of diameter d_3 containing the same amount of air. Assuming the isothermal process, derive an expression for d_3 as a function of d_1, d_2 the ambient pressure P_0 and the surface tension of soap solution in air. 2½

(c) A conical pointed shaft turns in a conical bearing (see Fig-Q1c). The gap between shaft and bearing is filled with heavy oil having the viscosity of SAE 30 at 30°C $\left(\mu = 2\times10^{-1} N\cdot s/m^2\right)$. Obtain the algebraic expression for the shear stress that acts on the surface

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of the conical shaft. Calculate the viscous torque that acts on the shaft. 3½

(d) What is apparent viscosity? Define *pseudoplastic* fluid and *dilatant*. 1½

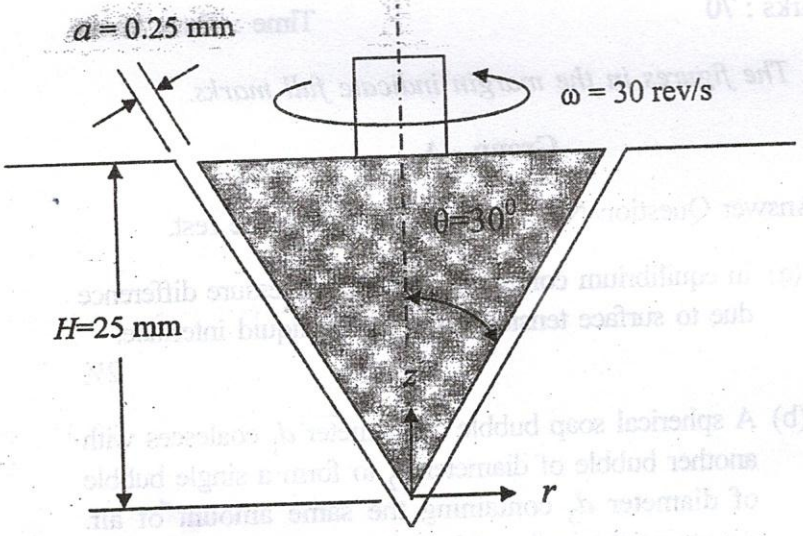

Fig-Q1c

2. (a) The velocity components for a steady flow are given as $u = 0, v = -y^3 - 4z, w = 3y^2 z$. Determine :

(i) Whether the flow field is in one, two or three dimensional,

(ii) Whether the flow is incompressible or compressible, and

(iii) The stream function for the flow. 6

(b) Air at standard conditions (absolute pressure 101.3 kPa and temperature 15°C : $\rho_{air} = 1.225\ kg/m^3$, $\mu_{air} = 1.781 \times 10^{-5}$ Pa.s) enters a compressor at 75m/s and leaves at an absolute pressure and temperature of 200 kPa and 345 K, respectively, and speed V=125 m/s. The flow rate is 1 kg/s. The cooling water circulating around the compressor casing removes heat at a rate of 18 kJ/kg of air. Determine the power required by the compressor. (Solve by application of *Reynolds Transport Theorem* **Only**) (Given: C_p of air 1.005 kJ/(kg·K)). 6

3. (a) The velocity field in a fluid medium is given by $\vec{V} = 3xy^2\hat{i} + 2xy\hat{j} + (2zy + 3t)\hat{k}$, Find the magnitudes and directions of (i) translation vector (ii) rotational vector and (iii) the vorticity of fluid element at (1,2,1) and at time $t = 3$. 6

(b) A square shaped fluid element is moving in flow fields with the following different conditions: i) $u = x,\ v = -y,$ ii) $u = y,\ v = x$ and iii) $u = -y,\ v = x$. Discuss and draw the change in shape of the fluid element for each of the cases mentioned above with mathematical reason. 6

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Group - B

Answer any *two* questions.

4. (a) Derive the Euler's equation in streamline coordinate system along stream wise direction with z-axis directed vertically upward. 5

(b) Deduce the Bernoulli equation from the previously obtained Euler's equation after considering the necessary assumptions. 3

(c) Air flows into the narrow gap of height, h between closely spaced parallel disks through a porous surface as shown in Fig-Q4c. If $V(r) = v_0 r/(2h)$ is uniform velocity in the r direction at position r, find an expression for the velocity component in the z direction $(v_0 << V_r)$. 4

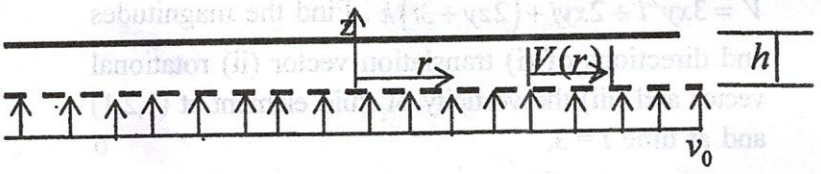

Fig-Q4c

5. (a) Derive the expression for actual discharge Q flowing through an open channel when measured by a V-notch; height of water flowing above the crest of the V-notch = H, velocity of approach = V_a and coefficient of discharge = C_d. 3

(b) Explain the working principle of venturimeter with a neat sketch and establish an expression of actual discharge (Q) through it. 4

(c) A horizontal venturimeter, with inlet and throat diameters 300 mm and 100 mm, respectively is used to measure the flow of oil of specific gravity 0.88. The pressure intensity at inlet is 130 kN/m^2 while the vacuum pressure head at the throat is 350 mm of Hg. Assuming $C_d = 0.92$ find, actual discharge (Q). 5

6. (a) A cylindrical gate has diameter of 3 m and length of 6 m as shown in Fig-Q6a. Find the (i) Magnitude (ii) Point of application and (iii) direction of the resultant force on the gate. Also find out the minimum weight of the gate so that it will not float away from the floor. 3+3+3+1

(b) Write down the conditions for stable equilibrium, unstable equilibrium and neutral equilibrium of unconstrained vessels in fluid in terms of metacentric height. 2

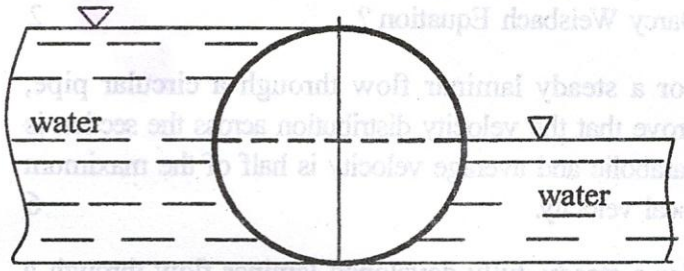

Fig-Q6a

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Group - C

Answer any *two* questions.

7. (a) What do you mean by fundamental units and derived units? Give examples. 2

   (b) State Buckingham Pi Theorem. 3

   (c) What are the repeating variables? How are these selected by dimensional analysis ? 3

   (d) Define the following dimensionless numbers and state their significance for fluid flow problems. 4

   (i) Reynolds Number

   (ii) Froude Number

   (iii) Mach Number.

8. (a) What is meant by Critical Reynolds Number ? 2

   (b) What is meant by Hydraulic Mean Depth? 2

   (c) What are the assumptions considered in deriving the Darcy Weisbach Equation ? 2

   (d) For a steady laminar flow through a circular pipe, prove that the velocity distribution across the section is parabolic and average velocity is half of the maximum local velocity. 6

9. (a) For a steady, fully developed laminar flow through a duct, the pressure drop per unit length of the duct $\Delta p/l$ is constant in the direction of flow and depends on the average flow velocity V, the hydraulic diameter

of the duct D_h, the density ρ, the viscosity μ of the fluid, using Buckingham Pi theorem find a relation among the variables. 6

(b) A smooth pipe of 80 mm diameter and 1000 m long is carrying water at the rate of 8 litres/sec. If kinematic viscosity of water is 1.5×10^{-6} m^2/s and value of coefficient of friction f is given by the relation $f = 0.0791/(Re)^{0.25}$ where Re is Reynolds No. Calculate

(i) Reynolds Number

(ii) Loss of head

(iii) Wall Shear stress. 6

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Q. No. ME - 331 / 057

B. Tech./Odd
2017-18/Reg

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MECHANICAL ENGINEERING

ME - 331

Full Marks : 70 Time : Three Hours

The figures in the margin indicate full marks.

Assume any data, suitably, if necessary.

Notations have their usual meanings unless stated otherwise.

Answer any *five* questions taking at least *two* from each half.

First Half

1. (a) Consider a control volume subjected to fluid pressure, static and dynamic forces, heat as well as work transfer. Through the multiple inlet and outlet ports fluid flow obeys the continuity principle in mechanics inside the control volume. With reference to such control volume, write down the mathematical expressions for momentum conservation principle, first law of thermodynamics, second law of thermodynamics, and entropy generation. Explain the existence of each term in each equation. 1+2+2+2

(b) Define entropy. A mass of m kg of a liquid of specific heat c at a temperature T_1 is mixed with an equal mass of the same liquid at temperature T_2. The system is thermally insulated. Show that the entropy change of

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the universe is given by $2mc\ln\left(\frac{T_1+T_2}{2\sqrt{T_1T_2}}\right)$. Argue that the entropy change of the universe is a non-negative quantity. 1+5+1

2. (a) First assume, if possible, that heat is an exact differential. Choose a suitable functional form of $P-V-T$ surface and perform an analysis to conclude that heat cannot be an exact differential and hence a path function. 7

(b) First assume, if possible, that work is an exact differential. Choose a suitable functional form of $P-V-T$ surface and perform an analysis to conclude that work cannot be an exact differential and hence a path function. 7

3. (a) Define heat reservoir. With reference to heat transfer interactions define the efficiency of a heat engine. A heat engine works with a limited capacity source and sink representative of a batch of fluid with mass m and heat capacity c. The temperatures of the source and sink are T_1 and T_2 to start with. Prove that the maximum work (W) that can be extracted from such arrangement is given by $W=mc\left(\sqrt{T_1}-\sqrt{T_2}\right)^2$. 1+1+5

(b) With reference to heat transfer interactions alone define the coefficient of performances of a heat pump, and refrigerator. A refrigerator operating between two identical bodies cools one of the bodies at a

temperature T_2. Both the bodies are at temperature T_1 to start with. Show that for this operation the minimum work required by the heat pump for a batch of fluid with heat capacity c is provided by

$$W=c\left(\frac{T_1^2}{T_2}+T_2-2T_1\right)$$ 1+1+5

4. (a) Derive an expression for air standard thermal efficiency of a Diesel cycle. 7

(b) Obtain an expression for mean effective pressure for air standard Diesel cycle. 7

Second Half

Assume any suitable data, if required.

Answer in short and to the point in your own language.

Symbols used in the answer script should be defined properly.

5. (a) Define the following terminologies :

(i) Margin of safety;

(ii) Factor of safety.

(b) List the important considerations which help the designer to decide the numerical value of factor of safety. Discuss in short.

(c) An air receiver consisting of a hollow straight cylindrical portion closed at both ends with hemispherical end closure. The air receiver is made of plain carbon steel 10C4. The length and internal

P.T.O.

diameter of the above-mentioned straight cylindrical portion are 1000 mm and 500 mm respectively. The wall thickness of the air receiver is 12 mm. The air receiver will be used to store air at a pressure of 5 MPa.

The ultimate tensile strength of steel 10C4 may be assumed as 340 MPa. Assume that the 12 mm thickness of wall of the air receiver includes a corrosion allowance of 3.5 mm for prevention of failure from corrosion. Also assume that the outside atmospheric pressure is negligible. Neglect the effect of welding.

Determine the following :

(i) Internal volume of air receiver;

(ii) Factor of safety with respect to ultimate tensile strength. 2+4+8=14

6. (a) What do you understand from the term "Thick cylinder" ? Explain with suitable example.

(b) A seamless steel pipe of 100 mm internal diameter is subjected to internal pressure of 12 MPa. It is made of steel whose yield strength and Poisson's ratio may be assumed as 230 MPa and 0.27 respectively. Assume a factor of safety of 2.5 and determine the thickness of the wall of the pipe. Use maximum shear stress theory of failure and maximum strain theory of failure. Compare the results obtained from two theories and give your comment on the results. Suitable formulae necessary for design calculations may be assumed.

(c) (i) What do you understand from the term "Thin cylinder"? Explain with suitable example.

(ii) Write the assumptions used for the design of thin cylinder as pressure vessel.

(iii) Discuss the above assumptions Q.6c(ii) on thin cylinder from the point of view of design and analysis of thin cylinder as pressure vessel.

1½+5½+(1½+2+3½)=14

7. (a) Derive an expression for the diameter d of a solid circular shaft subjected to axial torsion+ T and bending moment M on the basis of maximum shear stress theory of failure. Assume that symbol $[\tau]$ denotes allowable shear stress for the material of the shaft.

(b) A line shaft rotating at 200 rpm is to transmit 20 kW. The shaft may be assumed to be made of mild steel with an allowable shear stress of 40 MPa. Determine the diameter of the shaft, neglecting the bending moment on the shaft.

(c) A solid circular shaft of diameter 50 mm is to be connected to a pulley with a rectangular key to transmit an axial torque of 475 N-m to the pulley. The key is to be made from commercial steel for which yield strength may be assumed as 230 MPa. The standard cross-section of rectangular key for 50 mm diameter solid circular shaft is 16 mm × 10 mm. Assume a factor of safety of 3. Find the effective length of the rectangular key. 4+4+6=14

8. Write short notes on (any *four*) : $4 \times 3\frac{1}{2} = 14$

(i) Lame's line;

(ii) Compounding of cylinders;

(iii) Crowning of pulley;

(iv) Maximum shear stress theory of failure;

(v) Advantages of belt drive.

Q. No. ME 501 /

B.Tech / Odd
(17-18) / Reg

2017-18

PRODUCTION ENGINEERING II

ME 501

Full Marks : 70

Time : 3 hours

The figures in the margin indicate full marks.

FIRST HALF

Attempt Q. No. 1 and any *two* from the rest.

Notations carry their usual meanings

1. (*a*) Describe the mechanism of chip formation and explain Piispanen's model of card analogy in this respect.

   (*b*) How does a BUE form ? In your opinion, how the recrystallization temperature of workpiece material may effect the formation of BUE ?

   (*c*) In an orthogonal metal cutting, prove that: Shear strain, $\varepsilon_s = \cot\beta + \tan(\beta - \gamma)$ 6 + 2 + 5 = 13

2. (*a*) What is Merchant's second solution ?

   (*b*) Express F and N in terms of P_z and P_{xy} and prove these relations with the help of Merchant's circle diagram.

   (*c*) During an orthogonal cutting operation, the following data have been recorded: $a_1 = 0.127$mm, $a_2 = 0.228$ mm, b = 6.35 mm, $V_c = 120$ m/min, $\gamma = 10°$, $P_z = 56.7$ kgf and $P_{xy} = 22.7$ kgf. Find kinematic coefficient of friction at rake face and the exact power consumed in machining.

   1 + 5 + 5 = 11

3. (*a*) What are the various types of tool failure ? Explain them with neat sketches.

(*b*) Describe 'diffusion wear' as tool wear mechanism.

(*c*) To turn a mild steel component the power (specific energy) requirement is 0.1 HP/cm^3/min. The maximum power available at the machine tool spindle is 5 HP. If the cutting speed is 35 m/min and feed rate is 0.25 mm/rev, determine the following:

(a) maximum material removal rate,

(b) depth of cut,

(c) cutting force, and

(d) cutting (normal) pressure on tool. $4 + 2 + 5 = 11$

4. (*a*) What is "Taylor's modified tool life equation" ? Explain how the cutting parameters affect the tool life.

(*b*) Explain how 'γ' and 'φ' influence tool life.

(*c*) Prove that for an ideal cutting condition, the CLA value of surface roughness in a turning operation may be expressed as: $R_a = \dfrac{f}{4(\cot\varphi + \cot\varphi_a)}$. $3 + 4 + 4 = 11$

5. (*a*) Describe through-feed centreless grinding operation with a neat sketch.

(*b*) What do you mean by the following with regard to a grinding wheel ?

Grade, Structure

(*c*) How is a grinding wheel specified ? Illustrate the following specification of a grinding wheel:

D07 – A – 20 – H – V – 27DEL $4 + 5 + 2 = 11$

SECOND HALF

Answer Q. No. 6 and any *three* from the rest.

Answer should be brief and to the point.

Draw sketches as and when necessary.

6. (*a*) Define a deep hole.

(*b*) Name different operations which can be performed in lathe.

(*c*) Discuss the characteristic features of milling process. $1 + 2 + 2 = 5$

7. (*a*) Name three work holding devices generally used in lathe. Also mention their specific application.

(*b*) Discuss the functions of speed gear box in central lathe.

(*c*) With neat sketch, explain working principle of back gear drive. $5 + 2 + 3 = 10$

8. (*a*) Name the various methods available for taper turning in centre lathe. With a labelled sketch, explain the tail stock offset method for turning a taper of 85mm diameter to 75 mm diameter over a length of 200 mm, while the total length of the job is 300 mm in between centres.

(*b*) A grey cast iron shaft is turned in a centre lathe in 1 min 20 secs with a single cut. The shaft is 100 mm long and 75 mm in diameter. If the recommended cutting speed is 8m/min, calculate the used feed rate for the case.

(c) How is a centre lathe specified ? 5 + 3 + 2 = 10

9. (a) Show with neat sketches, the constructional features of a twist drill and label the important features. Also discuss the importance of point angle, chisel edge and lip.

(b) A hole of 25 mm diameter and 35mm depth is to be drilled in mild steel component. The cutting speed can be taken as 35m/min and feed rate 0.20mm/rev. Calculate the machining time and material removal rate. 6 + 4 = 10

10. (a) Distinguish between shaper and planer.

(b) Explain the operation of the quick return mechanism in a mechanical shaper. Also whow the variation of cutting speed and return speed with length of travel.

(c) Discuss the applications of a shaper in a machine shop. 2 + 6 + 2 = 10

11. (a) Draw a labelled diagram of horizontal knee and column-type milling machine and also mark the possible motion of components.

(b) Distinguish between up milling and down milling.

(c) Calculate indexing requirement for 62 divisions. 4 + 3 + 3 = 10

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Q. No. ME 502 / 144

B. Tech / Odd
(17-18) / Reg

2017-18

COMPUTER AIDED DESIGN AND MANUFACTURING

ME 502

Full Marks : 70 *Time* : 3 hours

The figures in the margin indicate full marks.

Answer should be brief and to the point.

Assume suitable data, if necessary.

GROUP A

Answer any *two* questions.

1. (*a*) What do you mean by synthetic curve and analytic curve. Briefly explain interpolation technique and approximate technique in respect of synthetic curve construction.

   (*b*) Explain with suitable example, geometry and topology in connection with solid modeling.

   (*c*) The starting and end points of a Hermite cubic spline segmentg are (0, 1) and (1, 2) respectively. The tangent vectors at the starting & end points are (0, 1) and (0, –1), respectively. Find the equation of the Hermite cubic spline segment. 4 + 2 + 6 = 12

2. (*a*) Find a parametric equation of cubic spline that starts at (1, 2), ends at (8, 4) and passes through two points (2, 4) and (6, 6). Use chord approximation technique.

   (*b*) Find the parametric equation of a Bezier curve with following four control points P_0 (2, 2, 0), P_1 (2, 3, 0), P_2 (3, 2, 0) and P_3 (3, 3, 0). 7 + 5 = 12

3. (*a*) Derive the composite homogenous transformation matrix for rotation of point (10, 8) about a point (3, 2). Perform an anti-clockwise rotation of 30° of the triangle A(1,1), B(2,3), C(5,2) about (-1,-1). Find the new co-ordinates of the vertex of the above triangle.

   (*b*) Write down the steps and corresponding basic homogenous transformation matrix for finding the composite homogenous transformation matrix for reflection of a point about a line y=x+5. (3 + 4) + 5 = 12

GROUP B

Answer any *two* questions.

4. (*a*) State the necessary and sufficient condition for multivariable unconstrained optimization problem.

   (*b*) Write down the steps involved in Newton-Raphson method for single-variable unconstrained optimization problem. Find the minimum value of the function:

   $f(x)=\frac{13}{20}\left\{1-x\tan^{-1}\left(\frac{1}{x}\right)\right\}-\frac{3}{4(1+x^2)}$, using Newton-Raphson method with the starting point x=0.2. Use ϵ=0.001 for termination. Carry out two iterations to solve this optimization problem. 4 + (2 + 6) = 12

5. (*a*) Define four D-H parameters for kinematic modeling ?

   (*b*) Fig. 1 shows the sketch of a robotic manipulator :

   (*i*) Establish link co-ordinate system in the robotic manipulator.

   (*ii*) Construct the link and joint parameters (D-H parameters) table.

   (*iii*) Determine the link transformation matrices.

   4 + (2 + 4 + 2) = 12

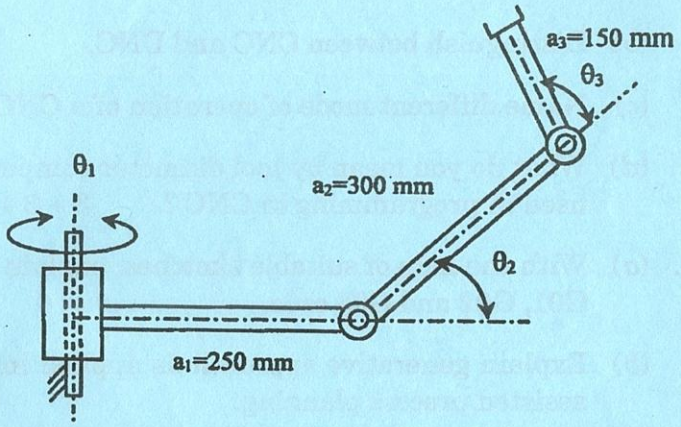

Fig. 1

6. (*a*) Mention few names of powder-based additive manufacturing processes.

   (*b*) Write down the major steps involved in a general additive manufacturing process.

   (*c*) With simple sketch, describe the basic process of the stereolithography apparatus (SLA).

(*d*) Mention some major process parameters on which performance of fused deposited modeling (FDM) depends. 2 + 2 + 6 + 2 = 12

GROUP C

Answer any *two* questions.

7. (*a*) What do you mean by numerical control ? How is it related to machining ?

   (*b*) Distinguish between CNC and DNC.

   (*c*) Name different mode of operation of a CNC system.

   (*d*) What do you mean by tool diameter compensation as used in programming in CNC ? 3 + 3 + 2 + 3 =11

8. (*a*) With the help of suitable sketches, explain the use of G01, G02 and G03 code.

   (*b*) Explain generative approach as applied in computer assisted process planning. 5 + 6 = 11

9. (*a*) Explain the importance of applying group technology in organization.

   (*b*) What do you mean by canned cycle ? Write a block line to show how to use stock removal cycle.

   (*c*) Explain the term 'Design For Manufacturing and Assembly' (DFMA). Enumerate the guidelines to be followed for implementation of DFMA. 4 + 3 + 4 = 11

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B.Tech/ Regular
2017-18

Thermal Engineering-II
ME503

Full Marks: 70 **Time: Three Hours**

Figures in the margin indicate full marks

FIRST HALF

Answer Question no. 1 and any three from the rest.

1. Discuss the relative advantages and disadvantages of internal combustion engines. 2

2. a) Describe with a suitable sketch the working principle of a four stroke cycle SI engine.
b) Discuss the differences between ideal and actual valve timing diagrams of a 4 -S petrol engine.
c) Compare the relative advantages and disadvantages of four stroke and two stroke cycle engines. 4 + 4 + 3 = 11

3. a) Discuss briefly the basic parameters by which performance of an engine is evaluated.
b) Describe how the I.P. of a multi-cylinder engine is measured?
c) A large diesel engine runs on four stroke cycle at 2000 rpm. The engine has a displacement of 25 liters and a brake mean effective pressure of 0.6 MN/m^2. It consumes 0.018 kg/s of fuel (calorific value = 42000 kJ/kg). Determine the brake power and brake thermal efficiency. 4 + 3 + 4 = 11

4. a) Discuss different factors which affect the frictional losses.
b) Define pour point and flash point, and discuss its importance in selecting the lubricating oil for IC engine.

c) How the lubricating oils are graded as per SAE?
d) What are 'Multi-grade oils'? What are their advantages?
3 + 3 + 2 + 3 = 11

5. a) Describe with a neat sketch the principle of working of a thermostatic controlled water cooling system.
b) Why overheating and overcooling of IC engine is harmful?
c) Compare the quantity of water required for 90 kW petrol and diesel engines in which water is raised in temperature by 27°C in passing through the jackets. In petrol engine the percentage of energy going to coolant is 32 percent and in diesel engine 28 percent. The efficiencies of petrol and diesel engines are 25 percent and 30 percent respectively.
4 + 4 + 3 = 11

6. a) What are the different methods used to improve the thermal efficiency of an open cycle gas turbine power plant?
b) In an air standard regenerative gas turbine cycle the pressure ratio is 6. Air enters the compressor at 1 bar, 27 °C and leaves at 217 °C. The maximum temperature in the cycle is 727 °C. Calculate the cycle efficiency, given that the efficiency of the regenerator and the adiabatic efficiency of the turbine are each 80%. Assume for air, the ratio of specific heats is 1.4. Also, show the cycle on a T-s diagram.
c) Explain the working of rocket propulsion. 3 + 4 + 4 = 11

SECOND HALF

Answer ant THREE Question

7. Distinguish between two undesirable operating phenomena 'Crank case dilution' and 'exhaust gas dilution' in S.I. engine, also indicate requirements to overcome these either of fuel characteristics or of mixture strength. How does intensity to resist knock alter with unit changes in octane rating from lower to higher range of the scale? Why are fuels of high octane ratings unsuitable in C.I .engine and detonation in S.I. engine more severe than knocking in C.I. engine? Which engine does both normal and abnormal combustion by auto ignition and which one does not have any scope for 'pre-ignition'? 2 + 2 + 2 + 2 + 2 + 2 = 12

8. What functions are served by high air velocity in mixing chamber of a carburetor and what are the draw-backs in simple design of carburetor? What is minimum requirement of absolute pressure head in fuel discharge tip above fuel level in float chamber to start injection? Why does sudden opening of throttle fail to accelerate the engine? Indicate advantages with multi venture in carburetor. What is the attachment in modern carburetor to enrich mixture at high throttle opening and why has it been misnomer?
2 + 2 + 2 + 2 + 1 = 11

9. Indicate in brief four important functional requirements of fuel injection system. What is actuated to meter fuel in common rail system? How and when does effective stroke of Jerk type injection pump increase? When does plungers of distributor type injection pump move radially inwards? How and when does nozzle valve of fuel injector move upward? What are the factors affecting distribution of fuel injected from nozzle in combustion chamber of C.I. engine? Indicate factors reducing size of injected fuel droplets coming out of fuel discharge nozzle. 2 + 1 + 1 + 1 + 2 + 3 + 2 = 12

10. a). Fuel consumption rate per shaft power of a four cylinder four stroke compression ignition engine was 0.22kg/kW- hr while developing 180 kW at 2250 rpm. Injection was done during 18° crank rotation when cylinder pressure changes from 40 bar to 60 bar with change in fuel discharge pressure

at orifice outlet 200 bar to 500 bar. Determine orifice diameter of each of the nozzles considering one injector per cylinder with coefficient of discharge of nozzle 0.7 and fuel density 850kg/cubic metre.

b). Main metering system of a down draught carburettor with fuel discharge orifice out-let at venturi throat was designed for A/F:: 16:1 when float chamber was vented to atmosphere at sea level($P_{atmospheric}$ = 1bar) and pressure at throat was observed as 0.75 bar. An air filter was connected at air inlet of mixing chamber to provide same air mass flowrate with same coefficient of discharge and pressure drop from inlet to throat was increased by 25 mm of mercury column. Determine pressure at venture throat and A/F ratio at venture outlet using this air filter. 6 + 5 = 11

11 i) Indicate limitations in mechanical ignition system.

ii) What condition must be reached by primary circuit of ignition coil on completion of optimum dwell period?

iii) Indicate requirement of advancement/retardation of spark timing with increase in engine speed and with reduction in load.

iv) What are the fundamental functions of pulse generator in transistorized coil ignition system?

v) Distinguish between continuous and timed injection system with respect to a) injector location, b) overall timing of injection and injection pressure.

vi) Indicate location, function and duration of operation of cold start injector in M.P.F.I. system.

2 + 1 + 2 + 2 + 2 + 2 = 11

HYDRAULIC MACHINES

ME – 504

Full Marks: 70 **Time: Three Hours**

The figures in the margin indicate full marks

(Assume atmospheric and separation heads are equivalent to 10m and 2.5m of water respectively)

Part One

Answer question 1 and any two from the rest

1. (a) What is the primary objective of using more than one jet in a Pelton wheel installation?
   (b) If the surface roughness factor of a Pelton wheel bucket is 90% and the deflection angle is 170°, what is the hydraulic efficiency?
   (c) Why are the draft tube not used in a impulse turbine installation?
   (d) In all modern reaction turbines, the velocity of whirl at exit is zero. What is the reason?
   (e) A fast Francis runner has dimensional specific speed 200 and unit power of 16. What is its unit speed?

2. (a) Define Specific Speed and Shape Factor? 1 x 5 = 5
   (b) Derive expression for the following unit quantities of a hydraulic turbine (i) Unit Speed (ii) Unit Discharge (iii) Unit Torque (iv) Unit Power.
   (c) A water turbine delivering 10MW power is to be tested with the help of a geometrically similar 1:9 model, which runs at the same speed as the prototype. Find power developed by the model assuming the efficiencies of the model and prototype are equal. Find also the ratio of the heads and ratio of the mass flow rate between the prototype and the model.

3. (a) Draw typical velocity triangles for fluid motion along a series of moving curve vanes, show that the energy per unit weight of fluid transferred between the fluid and the rotor is given as $H = \frac{1}{2g}[(C_1^2 - C_2^2) + (u_1^2 - u_2^2) - (w_1^2 - w_2^2)]$ where the symbols having its own nomenclature. 2+6+7=15
   (b) An inward flow reaction turbine has external and internal diameter as 1.08 m and 0.54 m. The turbine is running at 200 rpm. The width of the turbine at inlet is 240 mm and velocity of flow through the runner is constant and is equal to 2.16 m/s. The guide blades make an angle of 10° to the tangent of the wheel and discharge at the outlet of the turbine is radial. Determine (i) absolute velocity of the water at the inlet of the runner (ii) the velocity of whirl at the inlet (iii)the runner blade angle (iv) width of the runner at outlet.

4. (a) Derive the equation of theoretical power developed by a Pelton turbine and its hydraulic efficiency. 7+8=15
   (b) Derive an expression for the safe setting height of a reaction turbine and efficiency of a straight conical draft tube. 8+7=15

Part Two

Answer for any three questions

(2 marks reserved for overall impression)

1. (a) What is a positive displacement pump? Draw at least two characteristic curves explaining the performance of these pumps.

   (b) For a single acting reciprocating pump following data have been supplied: plunger diameter 75mm, stroke 150mm, suction head 3m, delivery head 12m, suction pipe length 5m, delivery pipe length 15m, suction pipe diameter 30mm, delivery pipe diameter 25mm. Assuming SHM of the plunger find the maximum safe speed of operation. 4+7=11

2. (a) What is an air vessel? While fitting it on the suction and delivery pipes of a reciprocating pump explain at least two of its advantages in each of the cases.

   (b) A 100mm diameter suction pipe of a double acting reciprocating pump having 200mm bore and 400mm stroke is fitted with a large air vessel. The pump runs at 120rpm and the piston assumes SHM. Calculate the rate of flow from or into the air vessel when the crank makes angles of 300, 900 and 1200 with IDC. At what crank angles will there be no flow? 4+7=11

3. (a) What is a rotodynamic pump? Operation of a multi-stage centrifugal pump is equivalent to that of the same number of single-stage centrifugal pumps connected in series – explain.

   (b) A centrifugal pump discharges 12000 litres of water per minute developing a head of 30m while running at 1450rpm. If the manometric efficiency is 0.75 and loss of head is 0.7m due to absolute velocity of water at outlet find the velocity of flow and the blade angle at outlet. The diameter of the impeller is 400mm. 4+7=11

4. (a) Applying angular momentum relationship for water passing through the impeller of the centrifugal pump develop the expression for Euler's head.

   (b) The internal and external diameters of the impeller of a centrifugal pump are 200mm and 600mm respectively. The vane tip angles of the impeller at inlet and outlet are 200 and 100 respectively. The widths at inlet and outlet are 50mm and 20mm. If the pump runs at 1800rpm, neglecting all losses, determine:

   (i) discharge assuming radial entry,
   (ii) angle at which water leaves the impeller,
   (iii) theoretical head developed bu the pump,
   (iv) power of the pump and
   (v) pressure head rise through the impeller. 4+7=11

5. Answer any three:

   (a) For a single acting reciprocating pump prove that the ratio of maximum to mean discharge is π.

   (b) Find out the percent of power saved in overcoming friction in delivery pipe of a double acting reciprocating pump by way of fitting a large air vessel close to the cylinder.

   (c) With a neat sketch explain the operation of a gear pump.

   (d) What is shut off condition? Explain specific speed of a centrifugal pump and its utility.

   (e) Derive fundamental equation for a centrifugal pump.

   (f) Why is priming needed? What are NPSH and Thoma's cavitation index/factor. 11

Q. No. ME 701 / 163

B.Tech / Odd
(17-18) / Reg

2017-18

MACHINE DESIGN III

ME 701

Full Marks : 70 *Time* : 3 hours

The figures in the margin indicate full marks.

Assume additional data if required.

Provide neat sketches wherever necessary.

GROUP A

Answer any *two* questions.

1. (*a*) A pair of precision cut forged steel helical gears has 20°-full depth involute teeth with 20° angle of helix. The pinion and gear has 17 teeth and 68 teeth respectively with 3mm module and 30mm face width. The material for the pinion has an allowable static bending stress of 145MPa and that for gear is 75MPa. Find the maximum power (kW) that the gear pair can transmit under the condition of static bending strength, if the pinion runs at 600rpm.

   (*b*) What will be the locus of the contact point in the above gear pair if the angle of helix is changed to 0°.

   (*c*) In a Miter gear, module is not same on two ends of the face. Which module is taken as standard and why?

   6 + 2 + 4 = 12

2. (*a*) What is the significance of back cone radius in straight bevel gear? -Explain briefly.

(*b*) A pair of straight tooth bevel gears transmits 7.5 kW at 960 rpm of the pinion under medium shocks (service factor=1.5). The gear shafts make an angle of 90° with each other. The wheels have teeth of 3.5mm module with 20° full depth involute profile and a face width of 28mm. Some of the dimensions of the bevel drive are listed below:

Item	Pinion (mm)	Gear (mm)
Small end pitch cone diameter	49.4	197.7
Large end pitch cone diameter	63	252
Back cone radius	32.5	520
Axial width	27	7

Assuming the wheels as solid truncated cones of steel having elastic modulus of 200HPa and density of 7.8gm/cc, estimate the dynamic load on the tooth using the Buckingham's method. The pitch error in each wheel may be taken as 20 microns. 3 + 8 = 11

3. (*a*) A worm gearbox consists of single enveloping 63 teeth worm gear of 4mm module engaging with a triple start worm having 32mm PCD. The tooth profile uses 20° normal pressure angle. Maximum power output from the gearbox is limited to 10kW with an input speed of 960 rpm. Average coefficient of friction at the tooth contact is 0.05. Calculate the following:

(*i*) Required kW rating of the electric motor driving the worm.

(*ii*) Radial and axial forces acting on the worm.

(*b*) List the changes that you observe in the operation of a worm gear pair if the thread form of the worm is altered from LH helix to RH helix. 4 + 4 + 3 = 11

GROUP B

Answer any *two* questions.

4. A vehicle spring has semi-elliptical laminated construction with the eye centres 110mm apart. The spring has 2 full length leaves and 8 graduated leaves held together by a 80mm wide central band. If the spring has to sustain a load of 9.5kN, then design the spring assuming width to thickness ratio as 6 for each leave. Allowable flexural stress for the material of the above spring is 540MPa. Take E=2 $\times 10^5$ MPa. 11

5. A square section forged steel bar in the form of a hook is used for carrying load suspended from it. The inner and outer radii of curvature of the hook are 30mm and 80mm respectively and the load acts through the centre of curvature. Find the maximum load that can be carried by the hook if the safe stress in either tension or compression is 70MPa. 12

6. A helical compression spring is made of 6mm diameter steel wire with squared and ground ends. The mean diameter of

the coil is 48mm. Calculate the maximum load that may be carried by the spring if the allowable shear stress for wire is taken as 325MPa. If the corresponding deflection of the spring is to be about 30mm, find the active number of coils and also the free length of the spring. Assume $G=8\times10^4$ MPa. 12

GROUP C

Answer any *two* questions.

7. (*a*) Give a neat sketch of a plate type friction clutch showing every element of it.

(*b*) Deduce the expression of torque transmission capacity of plate type friction clutch for single friction surface considering uniform wear between the plates.

(*c*) Design a Multi-plate clutch of alternate bronze and steel plates which has to transmit 6 kW power at 800 rpm. The inner radius is 38 mm and the outer radius is 76 mm. The coefficient of friction is 0.1 and maximum allowable pressure is 350 kN/m².

Determine:

(*i*) Axial force required

(*ii*) Total number of Discs.

(*iii*) Average Pressure.

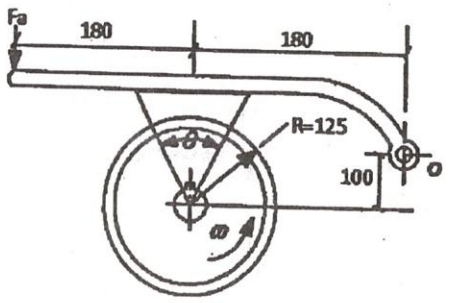
(*iv*) Actual Maximum pressure. 2 + 4 + 6 = 12

8. (*a*) What are the different types of mechanical brakes ?

(*b*) What are the advantages of a disk type brake ? Give two examples.

(*c*) A disk type brake has torque transmission capacity of 1500 N-m. Outer and inner radii of sector pad are 160 mm 110 mm respectively, coefficient of friction is 0.30 and maximum permissible pressure is 2.2 MPa. Use pads on both sides. Calculate the angular dimension of the pads.

(*d*) Determine the torque that may be registed by single small shoe block brake shown in Figure below, take $\mu = 0.3$ and Fa=625 N. 2 + 2 + 3 + 3 = 12



9. Design a suitable connecting rod for a car with following data:

Piston diameter: 80 mm

Stroke length: 90 mm

Length of the connecting rod: 150 mm

Maximum explosion pressure: 3.6 N/mm²

Weight of the reciprocating part: 2.6 kg

Speed: 4200 rpm

Compression ratio: 8:1 11

Q. No. ME 702 /

B.Tech / Odd
(17-18) / Reg

2017-18

THEORY OF MACHINES II

ME 702

Full Marks : 70

Time : 3 hours

The figures in the margin indicate full marks.

Answer to *five* questions selecting any *three* from Group A, and any *two* from Group B

GROUP A

Answer any *three* questions.

1. (*a*) With neat sketches explain the gyroscopic effect on ship due to motion of steering, pitching, and rolling.

   (*b*) A single cylinder engine with flywheel is shown in Fig. 1 which is taking right hand turn along with vehicle at 250 m radius at 85 kmph. find out engine bearing reaction due to gyroscopic action of the flywheel. The engine speed is 2500 rpm and is rotating clockwise when viewed from the front of engine. The moment of inertia of flywheel is 0.35 kgm². 14

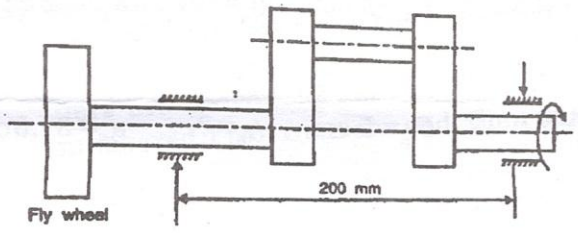


Fig. 1

2. (*a*) With a neat sketch explain the stability of four wheels vehicle and justify the stability condition of inner wheel when the vehicle is taking left turn.

   (*b*) Find out angle of heel necessary when a motor cycle is taking a turn of radius 35 m at a speed of 60 kmph. The motorcycle and its rider together weight is 2000 N and their combined centre of gravity is 0.55 m above the road when the motorcycle is upright condition. Each wheel is of 0.58 m diameter and has a moment of inertia of 1.0 kgm^2. The moment of inertia of rotating parts of engine is 0.15 kgm^2. The speed of engine rotating parts is 5 times that of the wheel. 14

3. (*a*) With neat sketches, explain internal and external balancing.

   (*b*) Fig. 2 shows a system of four rotating weights. Determine the magnitude and angular location of the balancing weights in planes A and B necessary to balance the system.

Given:

$W_1 = 2$ kg	$R_1 = 5$ cm	$\theta_1 = 0°$	$a_1 = 0$ cm
$W_2 = 2$ kg	$R_2 = 5$ cm	$\theta_2 = 270°$	$a_2 = 15$ cm
$W_3 = 2$ kg	$R_3 = 5$ cm	$\theta_3 = 180°$	$a_3 = 30$ cm
$W_4 = 2$ kg	$R_4 = 5$ cm	$\theta_4 = 90°$	$a_4 = 45$ cm
$W_A = ?$	$R_A = 5$ cm	$\theta_A = ?$	$a_A = 7.5$ cm
$W_5 = ?$	$R_5 = 5$ cm	$\theta_5 = ?$	$a_5 = 37.5$ cm

14

[*Continued*]

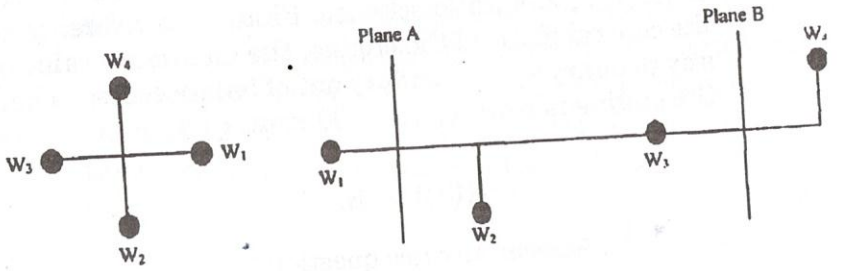


Fig. 2

4. (*a*) With a neat sketch, explain the balancing of single cylinder IC engine and derive the expression counter balance weight in terms of revolving weight and reciprocating weight.

   (*b*) In a V-twin engine, the angle between two cylinder centre lines is 2α. The rpm of the crank is N. The lengths of connecting rod and crank is l and r respectively where n=l/r. Show that $\tan\beta = \tan\theta.\tan^2\alpha$ where θ=crank angle and β=angle which the bearing reaction due to primary inertia force makes with the line of symmetry of the engine. 14

5. (*a*) With a neat sketch, derive the expression of inertia force of a multicylinder inline engine and write down necessay condition for balancing of the inertia force.

   (*b*) In a four cylinder in-line engine, the equivalent reciprocating masses are 1 kg per cylinder. The stroke is 12 cm, the length of the connecting rod is 22 cm, cylinders are spaced 12 cm apart. If the cylinders are numbered 1 to 4 from one end, then in a side view, the

[*Turn Over*]

cranks appear at successive intervals of 90° in the order 1, 3, 2, 4 anticlockwise. Find, with reference to the central plane of the engine, the maximum value of any primary and secondary out of balance effect when the engine is running at 2000 rpm. 14

GROUP B

Answer any *two* questions.

6. (*a*) Derive from first principles, a relation for the displacement of mass from the equilibrium position of a damped vibratory system with harmonic forcing.

(*b*) A machine part of a mass 2 kg vibrates in a viscous medium. Determine the damping coefficient when a harmonic exciting force of 25 N results in a resonant amplitude of 12.5 mm with a period of 0.20 second. If the system is excited by a harmonic force of frequency 4cycles/sec what will be the percentage increase in the amplitude of forced vibration when damper is removed. 14

7. (*a*) Explain the term 'torsionally equivalent shaft'. Establish an expression for equivalent length of torsionally equivalent shaft replacing a shaft of varying diameter over various portions of its length.

(*b*) Two rotors I_1 & I_2 having moment of inertia 168.75 kgm^2 and 405 kgm^2 respectively are connected by a stepped shaft which has 10 cm diameter and 30 cm length, 15 cm diameter and 16 cm length, 12 cm diameter and 12.5 cm length respectively from the rotor I_1, and 9 cm diameter and 40 cm length for the remaining portion upto the rotor of I_2 as shown in Fig. 3. Deterimine the frequency of the torsional vibrations. It is desired to have the node at the midsection of the shaft of 12 cm diameter by changing the diameter of the section having a 9 cm diameter. What will be the new diameter ? take G = 84 GPa. 14

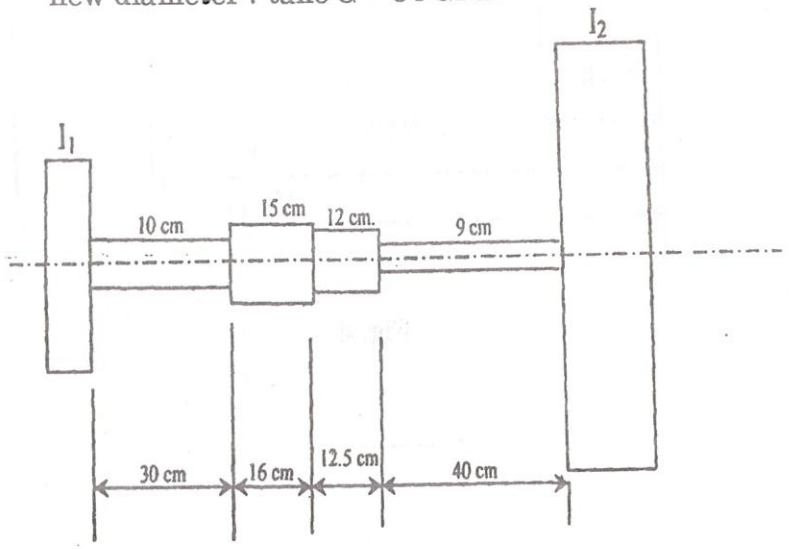


Fig. 3

8. A shaft 8 cm diameter and 2.8 m long between short bearings carries concentrated loads of 100 kg and 80 kg inclusive of the weight of the shaft as shown in Fig. 4 at 60 cm and 200 cm from left bearing. If E for shaft materials is 2×10^6 kg/cm^2, find the whirling speed by

(*i*) Dunkerley's Method

(*ii*) Raleigh's Energy Method 14

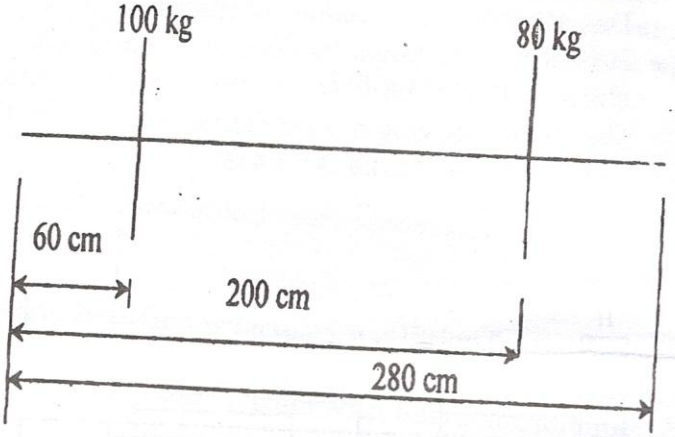


Fig. 4

Q. No. ME 710 / 152

B.Tech / Odd
(17-18) / Reg

2017-18

INDUSTRIAL MANAGEMENT & OR

ME 710

Full Marks : 70 *Time* : 3 hours

The figures in the margin indicate full marks.

SECTION A

Question No. 5 is compulsory and answer any *two* questions from Question No : 1, 2, 3 & 4.

1. (*a*) Mention six (06) important factors to be considered for efficient Plant Layout. 3

   (*b*) What are three (03) classic type of Layout ? Mention their advantages with examples. 6

   (*c*) Mention six (06) points of conflicts between the Line and Staff Executives with the arguments usually being posed by the Line Executives against Staff and Staff Executives against Line 3

   Or

   Mention the Merits and Demerits of Matrix Organization Structure

2. (*a*) Mention important ten (10) principles that help to form a good organization 5

(*b*) Explain the stages followed in an Organizational Planning Program through a schematic diagram indicating the Internal and External Activities associated to that. 7

3. (*a*) Describe nine (09) points towards the main objective of a good plant layout to reduce the operating cost. 2

(*b*) Explain Span of Control (SOC) with the job examples and mention four (04) points towards the basis of deciding SOC. 4

(*c*) Mention the Merits & Demerits (03 points) for each for (i) Line & Staff and Committee Organization Structure. 6

4. (*a*) Define Operations Research (OR) and explain the methodology to handle OR problems. 5

(*b*) Maximize $Z = 3X_1 + 2X_2$ through Graphical Method, subject to the conditions as under: 7

$X_1 + 2X_2 \leq 6$,

$2X_1 + X_2 \leq 8$,

$-X_1 + X_2 \leq 1$,

$X_1 \leq 2$ and X_1, X_2 are non-negative.

5. (*a*) Describe the basic three (03) characteristics of Standard form of Linear Programming Problems (LPP) 2

(*b*) Define the limitations of Graphical over Algebraic Method and Algebraic Method over Simplex Method. 4

(*c*) Maximize $6X_1 + 8X_2$ Subject to: 7

$X_1 + X_2 \leq 10$,

$2X_1 + 3X_2 \leq 25$,

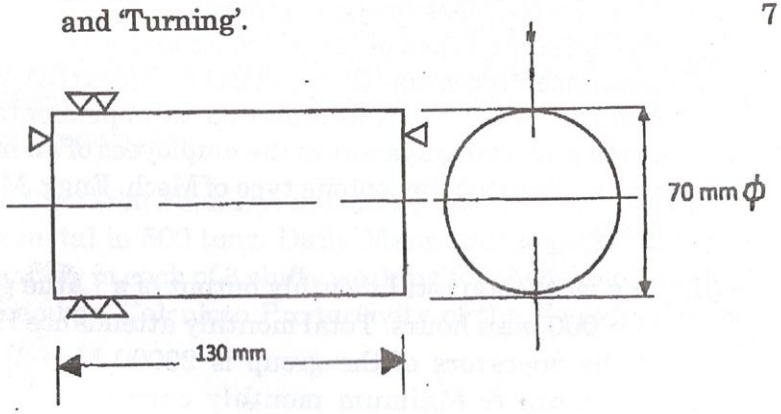
$X_1 + 5X_2 \leq 35$, and $X_1, X_2 \geq 0$ through SIMPLEX Tabular Form.

SECTION B

Question No. 6 is compulsory and any *two* from the rest

6. (*a*) What is the objective of Work Management ? Define Elapsed time, Normal Time, and Standard Time. What are the various allowances considered for the estimation of Allowed Time ? What are cutting regimes ? Design a direct 'Time Study Sheet' with the help of Stop watch. 4

(*b*) The drawing of the finished machine job is shown below. The different machining operations are 'Facing' and 'Turning'. 7



Cutting Speed = 100 m/min

Initial Size of round bar = 80 mmϕ

Initial length of round bar = 140 mm

Feed (f) = 1 mm/min

Depth of Cut (i) Rough = 5 mm (ii) Finish = 3 mm (maximum) (iii) Tool Approach = 3 mm (iv) Tool overrun = 3 mm

Cutting tool used is TC and material of the job is MS

Relaxation Allowance (RA) = 10 %

Crane Interfence Allowance = 15 %

Machine Conditioning Allowance = 15 %

Total Handling and Manipulation time for one complete loading, cutting and unloading cycle = 10 mins

Assume appropriate time standards for any other required elements not given here. Write the sequence of operation. Calculate Standard Time and Allowed Time.

(*c*) Mention the classification of Incentive Schemes. Write the different types of Incentive Schemes Define Performance Percentage (PP) and Bonus Index (BI). Write different steps from formulation to implementation stage and upto payment to the employees of an incentive scheme for the jobbing type of Mech. Engg. Maint. Shop. 5

(*d*) In a workshop total monthly output of a Lathe group is 10000 man hours. Total monthly attendance Hours of the operators of the group is 20000 Man Hours. Minimum & Mximum monthly earning (30 days)

potentials are Rs. 1000/- and Rs. 4000/- corresponding to 20 BI and 50 BI respectively. 7

PP-BI Table is given below:

PP	BI
40	20
60	30
100	50

Draw Incentive Straight Line (not to scale) and calculate monthly earnings of an operator at the present level of performance. Consider 25 working days in a month. Total Sundays and holidays are 5 in number. Consider 1/6 of total Sundays and holidays for bonus Calculation.

7. Describe the different factors that govern 'Plant Location'. Define Gross Margin, Cash Margin, Depreciation, Net Margin and Rate of Return (ROR) with an example. Mention the various advantages and disadvantages for selecting a Plant Site in Rural Area. 6

8. Write the objective of the Job Evaluation. What are the basic parameters considered during Job Evaluation ? What is Merit Rating ? Why is it required ? Define 'Production' and 'productivity'.

   In a Cast Iron Foundry, monthly (December) production of hot metal in 500 tons. Daily Manpower deployment is 10 numbers in each of 3 shifts working for the whole month of December. Calculate Productivity of the Foundry for the month. 6

9. Write short notes (any *two*) 6

(*i*) Flow Process Chart

(*ii*) Plant Maintenance

(*iii*) Manpower assessment

(*iv*) Industrial Safety.

Q. No. ME 720 / 54

B.Tech / Odd
(17-18) / Reg

2017-18

NON-CONVENTIONAL MACHINING

ME 720

Full Marks : 70 *Time* : 3 hours

The figures in the margin indicate full marks.

Notations and abbreviations carry their usual meanings.

All parts of a question to be answered together.

FIRST HALF

Answer Q. No. 1 and any *two* from the rest.

1. (*a*) Derive the expressions to determine the voltage and current in the machining gap while a spark occurs when an R - C relaxation generator is used in EDM process.

   (*b*) Draw neatly the theoretical and actual waveforms for both the voltage and current.

   (*c*) Do the actual voltage and current waveforms match with the theoretical ones ? Explain.

   (*d*) Write a short note on 'electronic pulse generator' in EDM.

   (*e*) How will you drill a curved hole in a metal workpiece. Explain with figure. 5 + 2 + 1 + 3 + 2 = 13

2. (*a*) What are various process inaccuracies in EDM ? Discuss them with necessary sketches.

   (*b*) Show various types of tool wear in EDM with a neat sketch.

   (*c*) Write a short note on process performance and accuracy in LBM ? Explain with neat sketches.

   (*d*) "The overall efficiency of an LBM system may be very low, say 0.3-0.5 % – explain. 4+ 2 + 3 + 2 = 11

3. (*a*) Describe the fundamental features of WEDM with a neat sketch.

   (*b*) Why is deionised water used as dielectric fluid in WEDM ?

   (*c*) Write a short note on 'Wire Electrode' in WEDM.

   (*d*) What is planetary EDM ? 4 + 2 + 3 + 2 = 11

4. (*a*) Define a laser.

   (*b*) Explain how a laser beam is generated in a tube containing lasing material exposed to a suitable pumping source.

   (*c*) Explain how laser beam is used in heat treatment of materials.

   (*d*) Write a note on 'laser cladding'. 1 + 3 + 3 + 4 = 11

5. (*a*) Describe the working principle of CHM with a neat sketch.

   (*b*) Write a note on 'Photochemical Machining'.

   (*c*) What are the limitations of CHM ? 4 + 4 + 3 = 11

SECOND HALF

Answer Q. No. 10 and any *two* from the rest.

6. (*a*) Draw a net sketch of a plasmatron used in Plasma Arc Machining (PAM) and explain the non-transferred mode and transferred mode of arc with their uses.

   (*b*) Discuss the material removal mechanism in Electron Beam Machining (EBM). What are the active forces in molten material dynamics ? 6 + 5 = 11

7. (*a*) What are the abrasives and their sizes used in Abrasive Jet Machining (AJM)?

   (*b*) Draw a labelled set up of AJM.

   (*c*) Write short notes on Stand-off distance and Nozzle, in context of AJM. 2 + 3 + 6 = 11

8. (*a*) What is equilibrium gap in Electrochemical Machining (ECM) ? Deduce the expression of equilibrium gap in terms of circuit parameters.

   (*b*) Why electrochemical grinding (ECG) is superior to conventional grinding ? Explain the process with appropriate diagram. 6 + 5 = 11

9. (*a*) State and explain any model of material removal in Ultrasonic Machining (USM) with the related assumptions.

(c) Design a half wave exponential mild steel horn of solid circular cross-section for rough cutting operation in USM whose large end diameter is 100 mm. The modulus of elasticity, poisson's ratio and density of steel are 210 GPa, 0.3 and 7.85 g/cc respectively. Assume any other data, if necessary. 5 + 6 = 11

10. (a) Describe the common defects and inaccuracies in ECM with reasons. Explain with suitable sketches.

(b) What are the desirable properties of electrolyte for ECM. Name some common electrolytes.

(c) Estimate the time required for drilling a circular hole of 10 mm diameter and 25 mm depth on an alloy sheet containing 74% Nickel, 20% Chromium and 6% Iron with 500A current by ECM. Write down any assumption made. 3 + 3 + 7 = 13

Element	Mol. Weight	Density (g/cc)	Valency
Ni	58.7	8.90	2
Cr	52.0	7.19	2,3
Fe	55.8	7.86	2,3

Q. No. ME 725 / 60

B. Tech / Odd
(17-18) / Reg

2017-18

THEORY OF ELASTICITY

ME 725

Full Marks : 70 *Time* : 3 hours

The figures in the margin indicate full marks.

Assume additional data if required.

Notations carry their usual meanings.

All parts of the same question to be answered together.

Answer Q. No. 1 and any *four* from the rest.

1. (*a*) What is the physical significance of stress invariants? 2

   (*b*) Write the stress matrix at a point of a shaft with general cross section under uniform torsion in terms of wrapping function. 2

   (*c*) What is meant by stress deviator ? 2

   (*d*) Explain Mohr's circle for three dimensional stresses. 4

   (*e*) What is strain rosette ? Draw the configuration of a Delta rosette and write down the expressions to find the Principal Stresses (derivation not required). 4

2. (*a*) Considering a tetrahedron derive Cauchy's stress formula. 5

(*b*) If the rectangular components of stress (in MN/m²) at a point are the same as in the matrix below, determine the unit normal of a plane parallel to the z axis on which the resultant stress vector is tangential to the plane.

$$\begin{bmatrix} 500 & 0 & 100 \\ 0 & -200 & 0 \\ 100 & 0 & 300 \end{bmatrix}$$ 5

(*c*) Explain Mohr's circle for three dimensional state of stress. 4

3. (*a*) The linear strain (ε_{PQ}) of two neighborhood points P and Q of a stressed body is expressed by

$\varepsilon_{PQ} = \varepsilon_{xx} n_x^2 + \varepsilon_{yy} n_y^2 + \varepsilon_{zz} n_z^2 + \varepsilon_{xy} n_x n_y$

$+ \varepsilon_{yz} n_y n_z + \varepsilon_{xz} n_x n_z$. Derive the expressions for principal strains and their directions. 9

(*b*) For the following stress field find the expression for body force distribution necessary to satisfy the equations of equilibrium.

$\sigma_x = -x + 200y^2$, $\sigma_y = 10(x^2 + 20z^3)$,

$\sigma_z = 10(20x^3 + 10z)$, $\tau_{xy} = x(z^3 + 100xy)$, $\tau_{yz} = 0$ and

$\tau_{zx} = 0$. 5

4. (*a*) Write the equations of equilibrium for a differential element of a stressed body in terms of Cartesian coordinates.

The cross section of the wall of a dam is shown in Fig. 2a. Water pressure acts on face OB. The stress at any

point (x, y) is given by $\sigma_x = -\gamma y, \sigma_y = \left(\frac{\rho}{\tan\beta} - \frac{2\gamma}{\tan^3\beta}\right)x +$

$\left(\frac{\gamma}{\tan^2\beta} - \rho\right)y, \sigma_2 = 0$, $\tau_{xy} = \tau_{yx} = -\frac{\gamma}{\tan^2\beta}x$ and

$\tau_{yz} = \tau_{zx} = 0$. Check if these stress components satisfy boundary conditions and the differential equations of equilibrium. γ and ρ are the specific weights of water and dam material respectively. 6

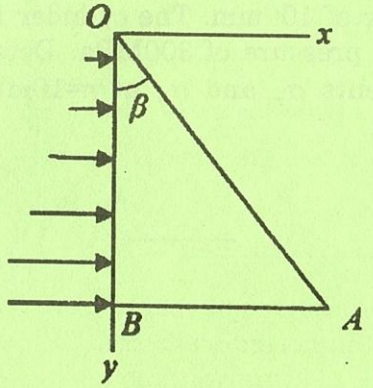


Fig. 4.a

(*b*) Derive the equations of equilibrium in cylindrical coordinate system with zero body force. 8

5. (*a*) A shaft of general prismatic cross-section is subjected to uniform torque T. Derive the equation for warping function (ψ).

Find the nine stress components (Cartesian) for a shaft having general cross section and subjected to uniform torque. Derive the expression for polar moment of inertia in terms of wrapping function. 9

(*b*) Prove that for an elliptical bar the warping function can be expressed by $\psi = \frac{b^2 - a^2}{b^2 + a^2} xy$, where a snd b are the semi-axes. Calculate maximum stress. 5

6. (*a*) Deduce the expression of radial and tangential stresses in pressurized thick walled cylinder starting from general stress equations of equilibrium (without body forces). 7

(*b*) A thick walled cylinder made of steel (E= 200GPa and v=0.29) has an inside diameter of 20 mm and outside diameter of 100mm. The cylinder is subjected to an internal pressure of 300MPa. Determine the stress components σ_r and σ_θ at r=10mm, r= 25mm and r=50mm. 7

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Q. No. ME 726 / 59

B.Tech / Odd
(17-18) / Reg

2017-18

INTRODUCTION TO FINITE ELEMENT METHOD

ME 726

Full Marks : 70 *Time* : 3 hours

The figures in the margin indicate full marks.

Answer any *five* questions.

1. (*a*) Solve the following second order differential equation using Galerkin method.

$$\frac{d^2y}{dx^2}+5\frac{dy}{dx}+7y=0$$

The boundary conditions are at $x=0, y=0$ and at $x=1$, $\frac{dy}{dx}=0$, Use four term solution.

Compare the solution with exact solution.

(*b*) Solve the following problem using Rayleigh-Ritz method

Minimize $I=\int_0^1 5\left(\frac{du}{dx}\right)^2 dx-10u(1)$; $u(0)=0$, Use three term solution. 8 + 6 = 14

2. (*a*) Derive the stiffness matrix and load vectors for three-

noded bar element from equation of equilibrium and using Galerkin method.

(*b*) Calculate the reaction forces, nodal deflections and stresses at each element of the bar shown in fig. 1. Use two 3-noded elements. 8 + 6 = 14

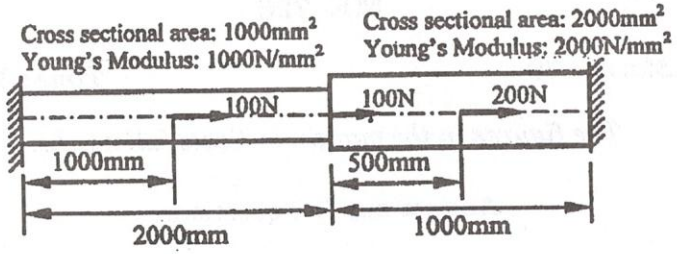

Fig. 1

3. (*a*) Calculate the reaction forces, nodal deflections and stresses at each element of the following truss as shown in Fig. 2. The cross sectional area of the truss elements is 2000 mm² and Young's modulus of the truss elements is 210GPa.

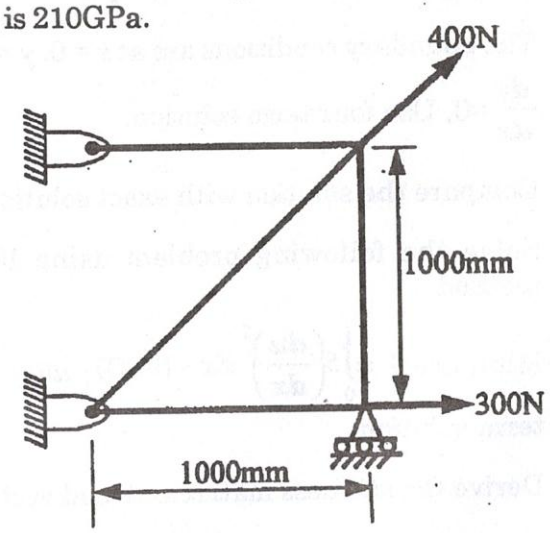

Fig. 2

(*b*) The temperature of the bar as shown in Fig. 3 is increased from 25°C to 65°C. Calculate the reaction forces, nodal deflections and stresses of each element. Use three 2-noded elements. 7 + 7 = 14

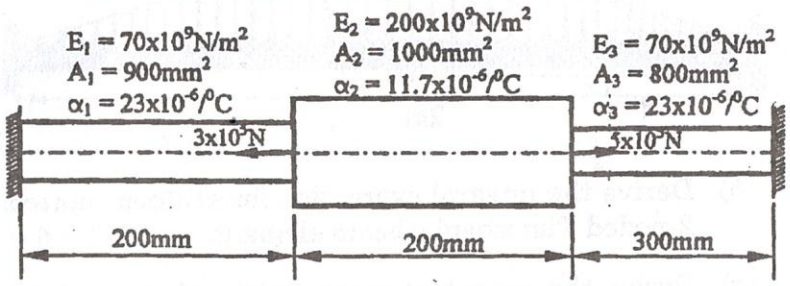

Fig. 3

4. (*a*) What do you mean by plane stress and plane strain conditions ? Write down the stress-strain relationship of plane stress and plane strain conditions.

(*b*) Derive the [B] matrix for a 3-noded triangular element.

(*c*) Calculate the global load vector for the following finite element mesh as shown in Fig. 4. There are two 3-noded triangular element in the mesh and each node having two degrees of freedon. 5 + 5 + 4 = 14

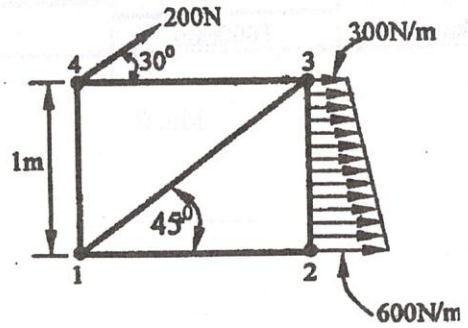

Fig. 4

5. (*a*) Determine the deflection and slope at the midpoint of the beam as shown in Fig. 5. Take E =200GPa and I = 4×10⁶mm⁴. Use two 2-noded Euler-Bernouli beam elements.

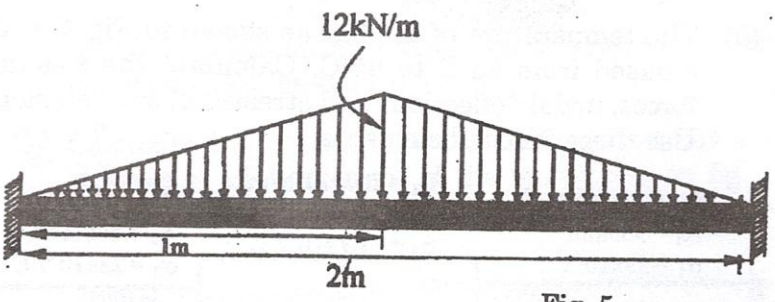

Fig. 5

(*b*) Derive the integral expression for stiffness matrix of 2-noded Timoshenko beam element. 8 + 6 = 14

6. (*a*) Derive the consistent mass matrix of two noded bar element.

(*b*) Calculate the natural frequencies and mode shapes of the bar as shown in Fig. 6. Use three 2-noded elements. 6 + 8 = 14

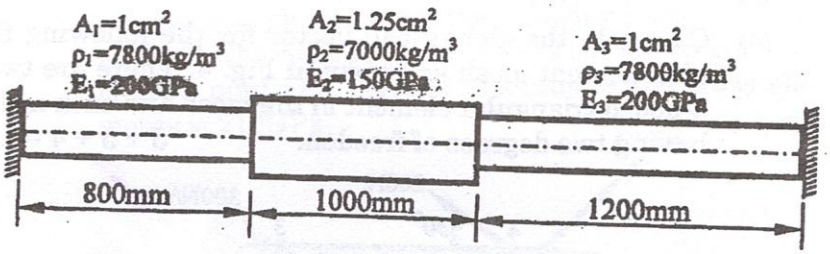

Fig. 6