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2018-19
SOLID MECHANICS
MEC- 301

Full Marks : 30 Time: Two Hours

Section – A (*Answer any two questions) (For neatness one mark).*

Q1. For the given state of stress (refer to Fig. 1), determine the maximum and minimum normal and shear stresses and their planes.

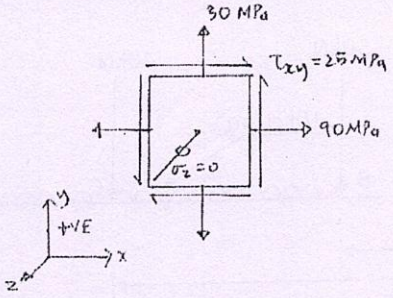

Fig. 1.

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Q2. A 10-m long simply supported beam is loaded as shown in Fig. 2. Determine the deflection and slope beneath the point load and maximum deflection. Given that E= 200 GPa and I = 10^6 mm^4.

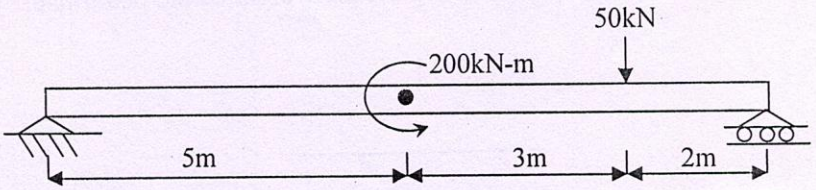

Fig. 2: A simply supported beam.

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Q3. For the beam and loading shown, determine the deflection at point D using Castigliano's theorem. Take E = 200Gpa, I = 28.9x10^6 mm^4

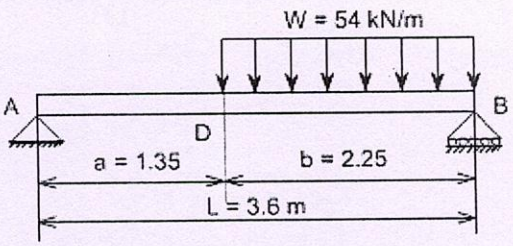

Fig. 3.

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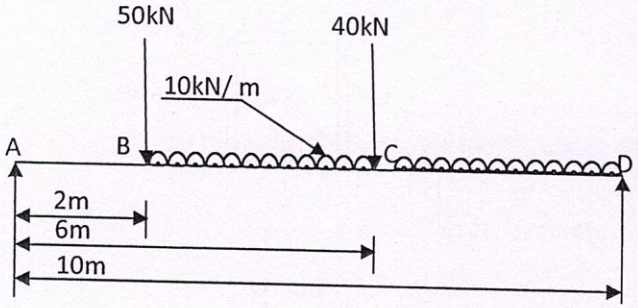
Section - B

Answer ALL questions.

Q4. A simply supported beam of length 10 m, carries the uniformly distributed load and two point loads as shown in the figure. Draw the S.F and B.M. diagram for the beam. Also calculate the maximum bending moment.



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Q5. A cast iron simply supported beam is in the shape of an inverted T, 22 cm depth overall, width of flange 15 cm, thickness of the web and flange 2 cm. If its length is 4 m, find what weight at the centre will cause a tensile stress of 1500 N/ cm^2 in the flange. What would be the maximum compressive stress then be? (Neglect the weight of the beam itself.)

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27/08/18

27/8/18

26/180

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B Tech/Odd Semester
Mid-Sem Exam/2018-19

THEORY OF MECHANISMS AND MACHINES
Subject Code - MEC 302

Time: Two hours **Full Marks:30**

All questions are of equal value. Figures in the margin indicate full marks.
Answer any three questions from Group A and any one question from Group B

Group – A

1. Answer any three of the following:
   (a) What is a quick return mechanism? – Explain it with a suitable diagram.
   (b) What is the difference between a mechanism and a machine? – Explain at least be three features.
   (c) What is a kinematic pair? What is the difference between a higher and a lower pair? Explain at least two pairs with neat sketches.
   (d) Grubler's criterion is a special case of Kutzbach's criterion for planar mechanisms – explain. State Grashof's law.
   (e) What is inversion? With neat sketches explain at least two inversions of a slider-crank mechanism.

   7.5

2. Answer any two of the following:
   (a) Derive the expression of angular acceleration of the connecting rod in the slider-crank mechanism with usual notations.
   (b) In a slider-crank mechanism the presence of the second term in the expression of the velocity/ acceleration of the slider is due to the finiteness of the connecting rod – explain in totality.
   (c) Derive the total acceleration with four components for a slider on a rotating link. Indicate and explain the presence of the Coriolis's acceleration component.

   7.5

3. (a) What is piston effort? Derive expression of Turning moment in term of piston effort.
   (b) A single cylinder vertical engine has a bore of 40 cm and a stroke of 50 cm. The connecting rod is 110 cm long. The mass of the reciprocating part is 150 kg. On the expansion stroke gas pressure is 10 MPa when the piston has moved through a distance of 10 cm from the TDC. If the engine runs at 750 rpm, determine:
   (i) piston effort,
   (ii) gudgeon pin load,
   (iii) cylinder wall thrust,
   (iv) crank pin effort and
   (v) turning moment on the crankshaft.

   2.5+5=7.5

4. (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 I C engine.
   (b) A certain machine requires a torque of $(5000 + 500\,\mathrm{Sin}\theta)$ N-m to drive it, where θ is the angle of rotation of shaft measured from certain datum. The machine is directly coupled to an engine which produces a torque of $(5000 + 600\ \mathrm{Sin}\,2\theta)$ N-m. The flywheel and the other rotating parts attached to the engine have a mass of 500 kg at a radius of gyration of 0.4 m. If the mean speed is 150 rpm, find :

(i) the fluctuation of energy,
(ii) the total percentage fluctuation of speed, and
(iii) maximum and minimum angular acceleration of the flywheel and the corresponding shaft position.

7.5

Group - B

5. (a) With suitable example, explain the term 'transmission angle' and discuss its importance in kinematic analysis of mechanism.

(b) Explain the concept of equivalent linkage with suitable example.

(c) Find expressions to determine the angles of the output link and coupler of a four bar (4R) mechanism. A four bar linkage with r_1=10 cm, r_2=20 cm, r_3=35 cm, r_4=40 cm and θ_1=0 deg. Compute the values of θ_4 when the driving crank is in the position θ_2=90 deg. Also compute $\dot{\theta}_4$, and $\ddot{\theta}_4$ when $\dot{\theta}_2 = 10$ rad/sec and $\ddot{\theta}_2$ =0. Here, r_1, r_2, r_3, and r_4 are link lengths of the fixed link, crank, coupler and follower respectively. All other symbols bear usual meanings.

2+0.5+5=**7.5**

6. (a) What do you understand by kinematic inversion? Explain the possible inversions of RRRP closed kinematic chain.

(b) What is redundant degree of freedom of a mechanism?

(c) Derive expressions to find the angular position, angular velocity and angular acceleration of the crank of a slider-crank mechanism for a given slider input. In the slider crank mechanism, position, velocity and acceleration of input slider are r_1=10.5 cm, $\dot{r}_1 = 50$ cm/sec and $\ddot{r}_1$ =350 cm/sec^2. The link length of crank and connecting rod are 4 cm and 9 cm respectively. Find the angular position, angular velocity and angular acceleration of crank. All other symbols bear usual meanings.

2+0.5+5=**7.5**

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MID TERM EXAMINATION-2018-19

FLUID MECHANICS

(MEC- 303)

Time- 2 Hours

Full Marks- 30

Group A (ANM)

(Answer any two questions)

1. (a) The shear stress in a fluid is given by the following equation $\tau = 0.05\ (du/dy)^2$. How is the fluid classified? **1**

   (b) A fluid field is given by $U = xyi + 2yzj - (yz+z^2)k$. Determine whether this is a possible steady incompressible fluid flow. If so, calculate the acceleration, angular velocity and velocity at the point (1,2,3). **6**

2. (a) What types of movement of a fluid element reveal the presence of shear stress? **1**

   (b) A three dimensional velocity field is given by **6**

   $U = Ax + 2By + C$

   $V = Ay + D$

   $W = -2Az + E$, where A, B, C, D and E are constant. Find

   (a) the linear strain rates for the velocity fields

   (b) the shear strain rates for the velocity fields

   (c) the rotational velocity

   (d) the vorticity

3. In some electrical measuring devices, the motion of a pointer mechanism is dampened by having a circular disc turn with the pointer in a container of oil. In this way, the extraneous rotations are damped out. What is the damping torque for an angular velocity $\omega = 0.2$ rad/sec, if the oil has a viscosity of 8×10^{-3} N-s/m^2, diameter of the circular disc $d = 75$ mm and depth of the oil in the container $y = 0.5$ mm? Neglect the effect on outer edge of the rotating plate. **7**

Group B (SCR)

(Answer ALL the questions)

4. (a) Check whether following velocity vector represents possible 3-D incompressible flow cases: **1**

$$\vec{V} = (y^2 + 2xz)\hat{i} + (-2yz + x^2yz)\hat{j} + (-\frac{1}{2}x^2z^2 + x^3y^4)\hat{k}$$

   (b) For an incompressible flow in $r\theta$ plane, the r component of velocity is given as, $V_r = \frac{-A\cos\theta}{r^2}$. Determine a simplest θ – component of velocity. **2**

5. A fluid flows down a plane inclined to horizontal by θ. The x axis is positive along the flow direction and y axis is perpendicular to the inclined plane and is positive in upward direction. The laminar film thickness, h along the positive y axis. The following assumptions are made to model the flow field using Continuity and Navier- Stokes **2.5+1.5+1**

equations:

(a) Steady flow.

(b) Incompressible flow *i.e.* $\rho =$ constant.

(c) No flow or variation of properties in the z direction; $w = 0$ and $\frac{\partial(.)}{\partial z} = 0$.

(d) Fully developed flow, so no properties vary in the x direction; *i.e.* $\frac{\partial(.)}{\partial x} = 0$.

Answer the following:

(i) Deduce the governing equation of the flow field.

(ii) Find the velocity profile.

(iii)Estimate the shear stress distribution.

Group C (SP/RNB)

(Answer all questions)

7. (a) What is the definition of the velocity potential? What is definition of the stream function? **2**

   (b) What is the condition for existence of *velocity potential function* in a flow field? **1**

8. (a) Derive the relation between tangential velocity and radius for free vortex flow. **2**

   (b) The *stream function* for an incompressible, two-dimensional flow field is $\psi = ay^2 - bx$ where a and b are constants. Is this an irrotational flow? **1.5**

   (c) Does a *velocity potential function* $\varphi = 2(x^2 + 2y - y^2)$ describe a possible incompressible flow field? **1.5**

14.09.18
1st Half (ME)

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B. Tech. /Odd
(18-19)/Midterm

2018-2019

ENGINEERING THERMODYNAMICS (MEC 304)

Full Marks: 30 **Time: Two Hours**

Answer all the questions

Assume suitable data if necessary. Notations used having their usual meanings if not mentioned otherwise.

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

   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 two different path. (2+2)

   c) A cylinder fitted with a piston has an initial volume of 0.1 m^3 and contains nitrogen at 140 kPa, 25°C. The piston is compressing the nitrogen until the pressure is 01 MPa and temperature becomes 140°C. During this compression process heat is transferred from nitrogen and work done on the nitrogen is 20 kJ. Determine the amount of heat transfer considering R= 0.29680 kJ/ kg.K and C_v = 0.7448 kJ/ kg.K. (2)

   d) 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? (2)

2. a) Draw the phase equilibrium diagram on Pressure-Volume, and Pressure-Temperature coordinates for a substance which shrinks in volume on melting at a temperature variation between (-)50°C and 150°C. (2)

   b) Steam is supplied from a boiler at a pressure of 18 bar and 99% dry, to a steam engine. It is found that the steam loses 16.75 kJ/kg as it flows through the pipe line, pressure remaining constant. Determine the dryness fraction and temperature of steam at the engine end of the pipe line.
   Given: @ 18 bar pressure: Saturation temp= 207.15°C, h_f = 884.79 kJ/kg, h_g = 2797.19 kJ/kg. (2)

   c) Draw the flow diagram of Rankine cycle and derive the efficiency of Rankine cycle in terms of specific enthalpy only. (2)

   d) A Rankine cycle has steam entering the turbine at 40 bar and 400°C. If the turbine output is 12000 kW, determine: (i) the dryness fraction at the turbine outlet, (ii) the thermal efficiency, and (iii) the mass flow rate of steam in kg/h, for condenser pressure of 8 kPa. Neglect the pump work. (4)

Steam pressure (bar)	Steam Saturation Temperature (°C)	Sp. Enthalpy (kJ/kg)			Sp. Entropy (kJ/kg.K)		
		h_f	h_g	h_{400}	s_f	s_g	s_{400}
40	250.3	1087.5	2800.8	3213.6	2.796	6.075	6.769
0.08	41.5	173.9	2577.0	-	0.593	8.228	-

3. a) Derive an expression of air standard efficiency and mean effective pressure for diesel cycle. (2+3)

b) The swept volume of a diesel engine working on dual cycle is 0.0053 m^3 and clearance volume is 0.00035 m^3. The maximum pressure is 35 bar. Fuel injection cut of takes place at 6 % of the stroke. The temperature and pressure at the start of the compression are 30°C and 0.9 bar, respectively. Determine the air standard efficiency and mean effective pressure of the cycle. (2+3)