

3 no 224

BITS-PILANI, DUBAI
DUBAI INTERNATIONAL ACADEMIC CITY, DUBAI
FIRST SEMESTER 2007-2008

COMPREHENSIVE EXAMINATION

ME UC 392 ADVANCED MECHANICS OF SOLIDS & KINEMATICS

Date: 07-01-2008

Marks: 40

Time: 3 hrs.

Weightage: 40%

Note: 1. Answer all questions.

2. Marks are shown in the brackets against each question.

3. Assume suitable data if required.

Question 1

The non zero stress components relative to the axes (x,y,z) are $\sigma_{xx} = -90$ MPa, $\sigma_{yy} = -50$ MPa, and $\sigma_{xy} = 6$ MPa.

- i) Determine principal stresses $\sigma_1 \geq \sigma_2 \geq \sigma_3$,
- ii) Find the mean and deviatoric stress tensors,
- iii) Calculate the maximum and octahedral shear stresses.

[8M]

Question 2

(a) The strain components at a point are given by:

$$\epsilon_x = 100 \times 10^{-6}, \epsilon_y = 50 \times 10^{-6}, \epsilon_z = 40 \times 10^{-6} \text{ and } \gamma_{xy} = 20 \times 10^{-6},$$
$$\gamma_{yz} = 10 \times 10^{-6},$$
$$\gamma_{xz} = 15 \times 10^{-6}.$$

- i) Find the strain components on an oblique plane whose normal has the direction cosines $1/\sqrt{3}, \sqrt{2}/\sqrt{3}, 0$.
 - ii) Find also the normal and shearing strains on this plane. [6M]
- (b) Explain briefly the relationship between stresses, strains and internal energy and complementary energy density functions. [2M]

Question 3

The crank of a slider crank mechanism is 150 mm and the connecting rod is 600 mm long. The crank makes 300 rpm in the clockwise direction. When it has turned 45° from the inner dead centre position, determine

- i) Acceleration of mid-point of connecting rod and
- ii) Angular acceleration of connecting rod.

Draw configuration, velocity and acceleration diagrams using graphical method.

[12M]

Question 4

In a compound gear train, the power is transmitted from a motor shaft to output shaft. The motor shaft is connected to gear 1 whereas the output shaft is connected to gear 4. The gears 2 and 3 are mounted on the same shaft. The gear 1 meshes with gear 2 whereas gear 3 meshes with gear 4. The motor shaft is rotating at 1200 rpm in the clockwise direction. The number of teeth on gears 1, 2, 3 and 4 are 25, 50, 20 and 40 respectively. Draw the sketch of compound gear train and find

i) velocity ratio and

ii) speed and direction of output shaft.

[4M]

Question 5

Draw a sketch of an epicyclic gear train in which arm is C is rotating at 80 rpm (anticlockwise). The arm carries two gears A and B having 32 and 40 teeth respectively. The gear A is fixed and the arm rotates about the centre of gear A. Find

i) the speed of gear B when A is fixed and

ii) the speed of B when A instead of being fixed, rotates at 160 rpm clockwise.

[8M]

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T E S T II (OPEN BOOK)

Max. Marks: 20

Duration: 50 Min.

Date: 06-12-2007

- **Answer all questions.**
 - **Assume any missing data.**
 - **Marks are shown in brackets against each question.**
 - **Text book and lecture/class notes are allowed.**
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Question 1

Draw the four bar chain with the following dimensions:

$AB = 75 \text{ mm}; BC = 175 \text{ mm}; CD = 150 \text{ mm}; AD = 100 \text{ mm}$ and AD , which is fixed perpendicular to the link AB . If the input link AB rotates at 120 rpm clock-wise, find the angular velocities of links BC and DC . Find also the velocity of point E on link BC , which is at a distance of 50 mm from C . **(8M)**

Question 2

Draw the horizontal engine reciprocating mechanism with the following dimensions:

The crank $OC = 100 \text{ mm}$; connecting rod $CP = 300 \text{ mm}$; the crank angle is 120° with the line of stroke.

If the crank has a velocity of 75 rad/s and an angular acceleration of 1200 rad/s^2 Find the velocity of piston and total acceleration of crank. **(8M)**

Question 3

Draw the free hand sketch of the compound gear train with the following details: The power is transmitted from the motor shaft, connected to gear 1 to the out put shaft, connected to gear 6. Gears 1, 3 and 5 are drivers, where as gears 2,4 and 6 are followers. Gears 2-3 and gears 4-5 are compounded. Find the train value if the number of teeth on gears 1,2,3,4,5, and 6 are 30,75,40,120, 28 and 70 respectively. The speed of motor shaft is 1200 rpm clock-wise. Show the directions of rotation of all the gears. **(4M)**

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TEST I

Max. Marks: 25

Duration: 50 Min.

Date: 21-10-2007

- Answer all questions.
 - Assume any missing data.
 - Marks are shown in brackets against each question.
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Question 1

The stress components at a point are given by $\sigma_{xx} = \sigma_{yy} = \sigma_{zz} = 50$ MPa, $\tau_{xy} = 10$ MPa, $\tau_{yz} = 20$ MPa, $\tau_{zx} = 15$ MPa. Calculate the strain invariants. The modulus of elasticity and Poisson's ratio are 200 GPa and 0.3 respectively. **(10M)**

Question 2

The stress components at a point are given by $\sigma_{xx} = 21$ MPa, $\sigma_{yy} = 12$ MPa, $\sigma_{zz} = 16$ MPa, $\tau_{xy} = 6$ MPa, $\tau_{yz} = 12$ MPa, $\tau_{zx} = 21$ MPa. Determine the stress vector on a plane normal to the vector $i + 2j + k$. **(10M)**

Question 3

A point on a machine component is subjected to stresses $\sigma_{xx} = 80$ MPa, $\sigma_{yy} = 60$ MPa, $\sigma_{zz} = 20$ MPa, $\tau_{xy} = 20$ MPa, $\tau_{yz} = 10$ MPa, $\tau_{zx} = 40$ MPa. Find the octahedral normal and shear stresses for this state of stresses. **(5M)**