

# BITS, PILANI DUBAI CAMPUS

First Semester 2012-13

## COMPREHENSIVE EXAMINATION (CLOSED BOOK)

Course Name: Advanced Mechanics of Solids & Kinematics

Course No: ME C392

Date: 03.01.2013

Weightage: 40%

Max Marks: 80

Duration: 3Hrs

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Note: 1. All questions carry equal marks

2. Assume logically missing data if any.

3. Drawings should be drawn using pencil and as per scale

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### Question 1

The known stress components at a point in a body, relative to the  $(x,y,z)$  axes, are  $\sigma_{xx} = 10 \text{ MPa}$ ,  $\sigma_{yy} = 40 \text{ MPa}$ ,  $\sigma_{zz} = 30 \text{ MPa}$ ,  $\sigma_{xz} = 20 \text{ MPa}$ ,  $\sigma_{xy} = \sigma_{yz} = 0$ . Determine normal and shear stresses on a plane whose normal vector is  $2\mathbf{i}+4\mathbf{j}+2\mathbf{k}$ , the stress invariants  $I_1, I_2, I_3$  relative to  $(x,y,z)$  axes, the principal stresses and orientation of principal axes.

### Question 2

The displacements of a machine part are given by the following relations:  $u = 0.00123xyz$ ,  $v = 0.00064xyz$ ,  $w = -0.00123xyz$ , where  $u, v, w$  are the  $x, y, z$  components of displacements. What is the displaced position of a point P on the machine part originally at  $x=2\text{m}$ ,  $y=1\text{m}$ ,  $z=2\text{m}$ . Determine all the normal and shear strains at point P. When the body is deformed, the particle at P: passes to the point P\*:  $(x^*, y^*, z^*)$ . Determine coordinates of the point P\* and the strain components for the state of strain at point P. Draw the free hand sketch showing original and deformed states, indicating clearly both P and P\*.

### Question 3

Consider the displacement field given by the following relations:  $u = C_1 y^2$ ,  $v = C_2 yz$ ,  $w = C_3 x^2$ , where  $(u, v, w)$  denote the  $(x, y, z)$  components of the displacements and  $C_1 = 0.02$ ,  $C_2 = 0.02$ ,  $C_3 = 0.04$ . When the body is deformed, the particle at P:  $(x=1, y=2, z=2)$  passes to the point P\*:  $(x^*, y^*, z^*)$ . Determine all the strain components and all the stress components for the state of strain at point P. Assuming  $E=200 \text{ GPa}$ , and  $\nu=0.3$ , find stress tensor.

### Question 4

Draw the configuration and velocity diagram for a vertical reciprocating engine mechanism with the following data:

Length of the connecting rod = 800 mm.

Radius of crank shaft = 200 mm

Angle of crank with the line of stroke =  $55^\circ$

If the crank shaft rotates at a constant speed of 1000 rpm, find the angular velocity of connecting rod, velocity of piston and velocity of mid point of connecting rod. Use analytical relative velocity method only.

### Question 5

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 output link DC rotates at 120 rpm clock-wise, find the angular velocities and angular accelerations of links BC and AB. Find also the velocity and of acceleration point E on link BC, which is at a distance of 70 mm from C. Use instantaneous center method and relative acceleration method (Drawings to scale)

**Question 6**

Draw an epicyclic gear train in which the arm **A** is rotating at 1200 rpm in clock-wise direction. The arm **A** carries two gears **B** and **C** having 35 and 45 teeth respectively. Find the speed of gear **C** if the gear **B** is fixed and the arm **A** rotates about the centre of gear **B** and the speed of **C** if the gear **B** instead of being fixed, makes 180 rpm clock-wise.

**Question 7**

Draw the profile of a cam, operating a knife-edged follower when the axis of follower passes through the axis of cam shaft from the following data:

Stroke of the follower	=	50 mm.
Least radius of cam	=	60 mm
Angle of outward stroke	=	$60^\circ$
Angle of next dwell	=	$45^\circ$
Angle of return	=	$90^\circ$

Remaining period is dwell. The displacement of the follower is to take place with SHM during both the outward and return strokes. Draw the follower displacement diagram and then construct the cam profile.

**Question 8**

Write a short notes on the following:(5×2= 10 Marks)

- (A). Castigliano's first and second theorems
  - (B) Anisotropic elasticity
  - (C).First law of thermodynamics related to solid mechanics
  - (D) Internal and complementary energies
  - (E) Stresses and Strains in terms of energy densities
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**BITS PILANI, DUBAI CAMPUS**  
**Dubai International Academic City, Dubai**  
**I Semester 2012-2013**

Course No: ME C392

Course title: Advanced Mechanics of Solids & Kinematics

Date: 25.11.12

Test II Regular (Open Book)

Max Marks: 20

Duration: 50 Min

Weightage: 20%

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- NOTE:**
1. Answer all questions
  2. Each question carries 10 marks
  4. Assume logically the data, missing if any
  5. Prescribed text book, hand-written class notes, lecture notes are allowed.
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**Question 1**

The crank of a slider crank chain mechanism for a horizontal engine is 150 mm and the connecting rod is 600 mm long. The crank makes 200 rpm in the clock-wise direction. When it has turned  $45^\circ$  from the inner dead centre position, find the velocities of piston angular velocity of connecting rod using instantaneous centre method. Draw the diagram to scale.

**Question 2**

Draw a four bar chain with the following dimensions: Fixed link AD = 4m; Driving link AB = 1.5 m; Driven link CD = 2.5 m; coupling link BC = 3 m; Angle BAD =  $60^\circ$ . Link CD revolves at 30 rpm. Find the angular velocities of the links AB and BC using relative velocity method.

[check  $\omega_B = 142.63^\circ/s$   $\omega_C = 98.46^\circ/s$ ]

*Wishing you all the best*

**BITS PILANI, DUBAI CAMPUS**  
**Dubai International Academic City, Dubai**  
**I Semester 2012-2013**

Course No: ME C392

Course title: Advanced Mechanics of Solids & Kinematics

Date: 11.10.12

Test 1- Regular (Closed Book)

Duration: 50 Min

Max Marks: 50

Weightage: 25%

- NOTE:**
1. Answer all questions
  2. Each question carries 10 marks
  3. Neat Free hand sketches should be drawn for all questions.
  4. Assume logically the data, missing if any
  5. Draw Mohr's circles on the answer booklet by choosing a Suitable scale. No graph sheet will be supplied.

**Question 1**

The known stress components at a point in a body, relative to the (x, y, z) axes, are  $\sigma_{xx} = 15 \text{ MPa}$ ,  $\sigma_{yy} = -55 \text{ MPa}$ ,  $\sigma_{zz} = 33 \text{ MPa}$ ,  $\sigma_{xz} = 22 \text{ MPa}$ ,  $\sigma_{xy} = \sigma_{yz} = 12 \text{ MPa}$ . Calculate normal and shear stresses on a plane whose intercepts on x, y and z axes are 2, 3 and 5 respectively.

**Question 2**

A plate in the side of a ship is made of an isotropic steel ( $E=200 \text{ GPa}$ , and  $\nu=0.3$ ). The plate is subjected to a uniform state of stress ( $\sigma_{xx} = 100 \text{ MPa}$ ,  $\sigma_{yy} = -20 \text{ MPa}$ ,  $\sigma_{zz} = \sigma_{xz} = \sigma_{xy} = \sigma_{yz} = 0$ ). Determine

- (a) the principal stresses and maximum shear stress.
- (b) the strain tensor

**Question 3**

The displacements of a machine part are given by the following relations:  $u = 0.00133xyz$ ,  $v = 0.00066xyz$ ,  $w = -0.00133xyz$ , where  $u, v, w$  are the x, y, z components of displacements. What is the displaced position of a point P on the machine part originally at  $x=1\text{m}$ ,  $y=1\text{m}$ ,  $z=2\text{m}$ . Determine the state of strain

$\epsilon_{xx}, \epsilon_{yy}, \epsilon_{zz}, \gamma_{xy}, \gamma_{xz}, \gamma_{yz}$  at the point P.

**Question 4**

The known stress components at a point in a body, relative to the (x, y, z) axes, are  $\sigma_{xx} = 15 \text{ MPa}$ ,  $\sigma_{yy} = -57 \text{ MPa}$ ,  $\sigma_{zz} = 36 \text{ MPa}$ ,  $\sigma_{xz} = 22 \text{ MPa}$ ,  $\sigma_{xy} = \sigma_{yz} = 0$ . Determine

- (a) normal and shear stresses on an equally inclined plane.
- (b) the stress invariants  $I_1, I_2, I_3$  relative to (x, y, z) axes and the principal stresses

**Question 5**

The stress components at a point are given by  $\sigma_{xx} = 70 \text{ MPa}$ ,  $\sigma_{yy} = 10 \text{ MPa}$ ,  $\sigma_{zz} = -20 \text{ MPa}$ ,  $\tau_{xy} = -40 \text{ MPa}$ ,  $\tau_{yz} = \tau_{zx} = 0$ . Draw the Mohr's circles and show the maximum shear stress.

Name: \_\_\_\_\_  
ID NO: \_\_\_\_\_

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**BITS PILANI, DUBAI CAMPUS**  
**MEC 392 Advanced Mechanics of Solids & Kinematics**  
**I SEMESTER 2012-2013**

**QUIZ II**

**Date: 30-10-12**  
**Duration: 20 Min.**

**Max. Marks: 7**  
**Weightage: 7%**

- Answer all questions.
  - Questions 1 to 4 carry 1 mark each and questions 5 and 6 carry 11/2 marks each
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**Question 1**

Write down the strains in 3-d terms of energy density functions.

**Question 2**

Draw the diagram representing internal energy and complementary energy density functions.

**Question 3**

What is the difference between internal energy and complementary energy.

**Question 4**

How do you distinguish between Castigliano's first and second theorems.

**Question 5**

If the force-deformation is linear for an MS rod of 20mm diameter, find the equation of variation and obtain the internal energy. Under a testing machine, it is found that the maximum elongation of 5 mm occurs under a load of 2 N.

**Question 6**

A cubic plate of 1200 cc is subjected to a stress of 2 GPa and 12  $\mu$ -strain. Find the total energy

DUBAI INTERNATIONAL ACADEMIC CITY

FIRST SEMESTER 2013-2014

**QUIZ I**

**NAME:** \_\_\_\_\_ **ID NO:** \_\_\_\_\_

Course No and Title: ME C392 Advanced Mechanics of Solids & Kinematics

Max.Marks: 16

Date: 25-09- 2012

Weightage: 8%

Duration: 20 mts.

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Note: 1. Answer all questions in the space provided below each question.

2. Marks are shown against each question.

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**Question 1**

**Write down the formula for normal stress on an oblique plane whose normal vector is  $li+mj+nk$**

**Question 2**

**Write down the deviatoric stress tensor with reference to the orthogonal principal stresses.**

**Question 3**

**Write down the cubic equation for finding principal stresses.**

**Question 4**

**What is the difference between principal stress invariants and general stress Invariants?**

**Question 5**

**Draw the free hand sketch of 3-d stress system, showing stresses on any 2 planes.**

**Question 6**

**Find the stress vector on an oblique plane which is equally inclined to the axes.**

**The normal stresses and shear stresses on x, y and z planes are respectively given by 10MPa, 20MPa, 10MPa, 20MPa, 15MPa and 40MPa respectively.**



**Question 7**

**Find the third stress invariant for a stress state with equal normal stresses i.e., 10MPa and equal shear stresses i.e. 5 N/mm<sup>2</sup>.**

**Question 8**

**Find the principal stresses for a system with all the stresses equal to 10 MPa.**