

BITS PILANI, DUBAI CAMPUS
ME C392 Advanced Mechanics of Solids & Kinematics
I SEMESTER 2011-2012

COMPREHENSIVE EXAMINATION

Max. Marks: 40

Weightage: 40%

Duration: 3 hrs.

Date: 12-01-2012

- Answer all questions.
 - Assume missing data if any logically.
 - 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 principal stresses and their directions. The modulus of elasticity and Poisson's ratio are 200 GPa and 0.3 respectively. Draw a neat free hand sketch of 3-d state of stress, showing all stresses. (6M)

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 normal and shear stresses on a plane normal to the vector $i + 2j + k$. Derive the formulae used. (6M)

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. Draw a neat free hands sketch of octahedral plane. (6M)

Question 4

Draw the horizontal engine reciprocating mechanism with the following dimensions: The crank OC = 100 mm ; connecting rod CP = 300 mm; the crank angle is 120° with the line of stroke. If the crank has a velocity of 75 rad/s, find the velocity of piston and velocity of mid point of connecting rod. Use instantaneous centre method and locate all the centres. (10M)

Question 5

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. (6M)

Question 6

Write short notes on following:

- (a) Castigliano's second theorem
 - (b) Internal energy and complementary energy density functions
 - (c) Kennedy's theorem on instantaneous centres.
- (6M)

BITS PILANI, DUBAI CAMPUS
Dubai International Academic City, Dubai
I Semester 2011-2012

Course No: ME C392

Course title: Advanced Mechanics of Solids & Kinematics

Date: 03.11.11

Test 1- Regular (Closed Book)

Duration: 50 Min

Max Marks: 25

Weightage: 25%

Question 1

The known stress components at a point in a body, relative to the (x, y, z) axes, are $\sigma_{xx} = 18 \text{ MPa}$, $\sigma_{yy} = -50 \text{ MPa}$, $\sigma_{zz} = 32 \text{ MPa}$, $\sigma_{xz} = 24 \text{ MPa}$, $\sigma_{xy} = \sigma_{yz} = 0$.

- (a) Find the principal stresses and
- (b) Draw the Mohr circle and find the shear stresses corresponding to 15 MPa and 20 MPa and locate these points on the circles.

[10]

Question 2

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 $C_1 = 0.02$, $C_2 = 0.04$, $C_3 = 0.07$. When the body is deformed, the particle at P: $(x=2, y=2, z=3)$ passes to the point P*: (x^*, y^*, z^*) . Determine

- (a) coordinates of the point P*.
- (b) the strain components for the state of strain at point P.
- (c) the normal strain at P in the direction of line PQ having direction ratios 0.6, 0 and 3. Draw the free hand sketch showing the deformed and un deformed line element.

[5]

Question 3

A plate in the side of a ship is made of an isotropic steel. 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) Find the normal and shear stresses on an oblique plane having 2, 3 and 4 as intercepts on x, y and z-axes respectively and
- (b) Derive the formula used for finding normal stress.

[10]

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T E S T II (Open Book)

Marks: 20
Weightage: 20%

Duration: 50 Min.
Date: 22-12-2011

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- Prescribed text book and hand-written class notes are only allowed.
 - Answer all questions.
 - Marks are shown in brackets against each question.
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Question 1

Draw a free hand sketch proportionate to data of a compound gear train of 5 gears, in which the gear 1 and gear 5 are fixed to the input and output shafts respectively. The number of teeth on gears 1, 2, 3, 4 and 5 are 40, 50, 60, 70 and 80 respectively. If the input shaft rotates at 1000 rpm in counter clock-wise direction, find the magnitude and direction speed of output shaft. Gears 2-3 and 4-5 are compounded. **[4M]**

Question 2

The length of crank and connecting rod of a horizontal reciprocating engine are 150 mm and 450 mm respectively. The crank is rotating at 500 rpm. Find angular velocity of connecting rod and velocity of piston when the crank has turned 30° from inner dead centre by drawing the configuration, diagram to scale using instantaneous centre method. **[10M]**

Question 3

A system of 3 bars connected in such a way that they form a triangular stress with one of them as frame and other two stress bars pinned together to support a vertical and horizontal loads of 2 kN and 1kN respectively. All the bars are identical in length. Find the vertical deflection at the pin joint bars using Castigliano's theorem if the areas of their cross section are 100 mm^2 and 200 mm^2 with their respective moduli as 210 GPa and 120 GPa. Draw the free hand sketch proportionate to data. **[6M]**

NAME: _____

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QUIZ II

Max. Marks: 14

Duration: 20 Min.

Weightage: 7%

Date: 14-12-11

- Answer all questions.
 - Marks are shown in brackets against each question.
-

Question 1

Write down the properties of instant centres in a mechanism.

[2M]**Question 2**

How many instant centres exist in a 8-bar mechanism? Give the relation used.

[2M]**Question3**

State Castigliano's first and second theorems and briefly explain their difference.

[2M]

Question 4

Draw the free hand sketch showing the internal and complementary energies.

[2M]

Question 5

Define instantaneous centre and explain briefly the location of instant centre for a piston.

[2M]

Question 6

Express normal and shear stresses in terms of energy density functions.

[2M]

Question 7

State the first law of thermodynamics, applied to solid mechanics and give its significance..

[2M]

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Q U I Z I

Max. Marks: 16

Weightage: 8%

Duration: 20 Min.

Date: 05-10-12

- Answer all questions.
 - Marks are shown in brackets against each question.
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Question 1

Draw the free hand sketch of octahedral plane and write down the formula for octahedral shear stress. [2M]

Question 2

Find the first and second stress invariant for the following stress state: [3M]

- (a).Stresses on x-plane:12 MPa, 13 MPa and 10 MPa
- (b) Stresses on y-plane: 13MPa,21 MPa and 14 MPa and
- (c) Stresses on z-plane: 10MPa, 14 MPa and 18 MPa

Question 3

Calculate the principal stresses on z-x plane using formula. The normal stresses on z and x plane are 40MPa and 35 MPa and shear stress is 40MPa. [2M]

Question 4

Draw the free hand sketch, showing the stresses on negative z-plane.

[2M]

Question 5

Find the stress tensor if the following stresses are acting on different planes as shown below :

1. Stresses on x-plane: 2MPa, 1 MPa and 1MPa
2. Stresses on y-plane: 1MPa, 3 MPa and 2MPa and
3. Stresses on z-plane: 1MPa, 2 MPa and 4MPa

[2M]

Question 6

Find the normal and shear stresses on an oblique plane whose normal vector is $2i+2j+4k$ with the following stresses on x, y and z-planes respectively: **[3M]**

- (a) Stresses on x-plane: 25 MPa, 20 MPa and 10 MPa
- (b) Stresses on y-plane: 20 MPa, 35 MPa and 24 MPa
- (c) Stresses on z-plane: 10 MPa, 24 MPa and 40 MPa

Question 7

Write down the formulae for stress vector on oblique plane and draw its free hand sketch. **[2M]**