

BITS, PILANI – DUBAI
Dubai International Academic city
ME C392 Advanced Mechanics of Solids & Kinematics
I SEMESTER 2010-2011

COMPREHENSIVE EXAMINATION

Max. Marks: 80
Weightage: 40%

Duration: 3 hrs.
Date: 27-12-2010

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

The displacements of a machine part are given by the following relations:
 $u = 0.00130xyz$, $v = 0.00067xyz$, $w = -0.00134xyz$, 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 $x=1.2m$, $y=1.4m$, $z=2m$. Determine the state of strain $\epsilon_{xx}, \epsilon_{yy}, \epsilon_{zz}, \gamma_{xy}, \gamma_{xz}, \gamma_{yz}$ at the point P. [8M]

Question 2

The stress components at a point are given by $\sigma_{xx} = 70$ MPa, $\sigma_{yy} = 10$ MPa, $\sigma_{zz} = -20$ MPa, $\tau_{xy} = -40$ MPa, $\tau_{yz} = \tau_{zx} = 0$. Determine stress invariants, principal stresses and their directions. [10M]

Question 3

A plate in the side of a ship is made of an isotropic steel ($E=207$ GPa, and $\nu=0.3$). It is subjected to a uniform state of stress ($\sigma_{xx} = 110$ MPa, $\sigma_{yy} = -25$ MPa, $\sigma_{zz} = \sigma_{xz} = \sigma_{xy}$, $\sigma_{yz} = 10$ MPa). Determine the stresses on an oblique plane which is equally inclined to x , y and z -axes and also find the principal strains. [12M]

Question 4

- (a) Explain briefly both the Castigliano's theorems. [3M]
(b) Derive the stresses and strains in terms of energy densities. [5M]

Question 5

Define the shear centre and locate the shear centre for the I- channel section, which has identical rectangular sections on the top and bottom. Draw the free hand sketch. [6M]

Question 6

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° from the inner dead centre position, find the velocities of piston, connecting rod and mid points of crank and connecting rod using instantaneous centre method. Draw the diagram to scale. [12M]

Question 7

- (a) In a compound gear train of 4 gears (gear 1 and gear 4 are attached to input and output shafts, gear 2 and gear 3 are compounded). The input shaft is rotating at 1000 rpm in counter-clockwise direction. The number of teeth on gears 1, 2, 3 and 4 are 30, 70, 40 and 110 respectively. Draw the gear train and find the magnitude and direction of speed of output shaft. [5M]
- (b) Draw an epicyclic gear train in which the arm A is rotating at 80 rpm in counter clock-wise direction. The arm A carries two gears B and C having 32 and 40 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 160 rpm clock-wise
- [7M]

Question 8

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	=	60 mm.
Least radius of cam	=	60 mm
Angle of outward stroke	=	50°
Angle of next dwell	=	40°
Angle of return	=	80°

Remaining period is dwell. The displacement of the follower is to take place with simple harmonic motion during both the outward and return strokes. Draw the follower displacement diagram and then construct the cam profile. [12M]

BITS – PILANI, DUBAI
Dubai International Academic City, Dubai
I Semester 2010-2011

Course No: ME C392

Course title: Advanced Mechanics of Solids & Kinematics

Date: 28.11.10

Test 2- Regular (Open Book)

Max Marks: 20

Duration: 50 Min

Weightage: 20%

Note:

1. Marks are shown against each question.
2. Assume any missing data logically.
2. Text book/hand-written class notes are only allowed.

Question 1

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°

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 instantaneous centre method only for finding velocities. [7]

Question 2

(a) Derive an expression for strain energy density of an isotropic material [4]

(b) For the following 3-d stress state of anisotropic material, write down all the stresses in terms of elastic coefficients.

$\sigma_{xx} = 10 \text{ MPa}$, $\sigma_{yy} = 20 \text{ MPa}$, $\sigma_{zz} = 12 \text{ MPa}$, $\sigma_{xy} = 14 \text{ MPa}$, $\sigma_{xz} = 10 \text{ MPa}$, $\sigma_{yz} = 5 \text{ MPa}$.

$\epsilon_{xx} = 0.1\mu$, $\epsilon_{yy} = 0.2\mu$, $\epsilon_{zz} = 0.3\mu$, $\gamma_{xx} = 0.25\mu$, $\gamma_{xz} = 0.25\mu$,

$\gamma_{yz} = 0.25$. [3]

Question 3

(a) Calculate the potential and complementary energies of a 2 m long steel bar of 50 mm diameter, subjected to a load of 2 kN. Assume that the bar is linearly elastic. [3]

(b) Find the internal and complementary energy densities for a steel rod of 1.5 m length with 100 mm^2 cross section. It is subjected to a tensile stress of 20 MPa. [3]

BITS – PILANI, DUBAI
Dubai International Academic City, Dubai
I Semester 2010-2011

Course No: ME C392

Course title: Advanced Mechanics of Solids & Kinematics

Date: 17.10.10

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) Calculate normal and shear stresses on a plane whose intercepts on x, y and z axes are 2, 3 and 5 respectively.
- (b) Draw the Mohr circle and find the nature of normal and shear stresses on an oblique plane inclined at angle of 30° in clock wise direction to the x- axis.

[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 $C_1 = 0.01$, $C_2 = 0.03$, $C_3 = 0.06$. When the body is deformed, the particle at P: (x=1, y=0, z=2) 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 cosines: $l = 0.6, m = 0, n = 0.8$. Draw the free hand sketch showing the deformed and un deformed line element.

[8]

Question 3

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

[7]

Name: _____

ID NO: _____

BITS, PILANI – DUBAI
ME C392 Advanced Mechanics of Solids & Kinematics
I SEMESTER 2010-2011
QUIZ II

Marks: 07

Date: 06-12-2010

Duration: 20 Min.

- Answer all questions.
- Put $\sqrt{\quad}$ mark in the brackets provided against the suitable answer.
- Marks are shown in brackets against each question.

SECTION A

Question 1 Which of the following is related to instantaneous centre. [1/2M]

- A rotation []
- B translation []
- C both translation and rotation []
- D none of the above []

Question 2 Which of the following is related to Kennedy's theorem? [1/2M]

- A absolute motion []
- B relative motion []
- C translation only []
- D rotation only []

Question 3 The instantaneous centre for a piston is located on a line [1/2M]

- A parallel to the line of stroke. []
- B normal to the line of stroke. []
- C parallel to the length of crank shaft. []
- D perpendicular to the length of crank shaft []

Question 4 How many instant centres will be there in a horizontal reciprocating engine mechanism. [1/2M]

- A 5 [] B 6 []
- C 4 [] D 2 []

Question 5 Which of the following gear trains is used in watches? [1/2M]

A simple []

B compound []

C epicyclic []

D inverted. []

Question 6 Which of the following is true for meshing gears. [1/2M]

A both the gears must rotate with same speed []

B both the gears must have equal number of teeth []

C circular pitch of both the gears must be equal []

D none of the above. []

SECTION B

Question 7 If a 2 m long link is rotating at 1000 rpm about a fixed point, find the velocity of its mid point. [1M]

Question 8 Draw the free hand sketch of a horizontal reciprocating mechanism and locate the instantaneous centre of its connecting rod [2M]

Question 9 Draw the free hand sketch of a compound gear train of 4 gears, showing clearly the directions of rotation. [1M]

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I SEMESTER 2010-2011

QUIZ I (REGULAR)

Max. Marks: 08

Duration: 20 Min.

Date: 10-11-2010

- Answer all questions.
- Put \surd mark in the brackets provided against the suitable answer.
- Marks are shown in brackets against each question.

SECTION A

Question 1 Which of the following is related to internal energy density **[1/2M]**

- A stress only []
- B stress and strain []
- C strain only []
- D none of the above []

Question 2 First law of thermodynamics applied to solid mechanics, contains only the following parameters: **[1/2M]**

- A work and internal energy. []
- B heat and work []
- C kinetic energy and heat []
- D none of the above []

Question 3 Area of the stress – strain diagram is the sum of the following: **[1/2M]**

- A internal energy and potential energy. []
- B internal energy density and complementary energy density. []
- C potential energy and complementary energy []
- D none of the above. []

Question 4 Strain energy density of anisotropic materials contains
The following number of elastic coefficients [1/2M]

A 5 [] B 6 []

D 50 [] D 36 []

Question 5 Strain energy density of isotropic material depends only on [1/2M]

A principal stresses. []

B shear strains []

C shear stresses []

D principal strains. []

Question 6 Which of the following statements is true for homogeneous materials [1/2M]

A physical properties are constant []

B physical properties vary []

C chemical properties are invariant. []

D thermal properties are constant []

SECTION B

Question 7 Express normal stresses in terms of internal energy density. [2M]

Question 8 Express shear strains in terms of complementary internal energy density [2M]

Question 9 State Castigliano's first theorem and explain briefly in what way it is related to the second theorem. [1M]