TECHNICAL UNIVERSITY OF MOMBASA

DEPARTMENT OF MECHANICAL AND AUTOMOTIVE ENGINEERING

FOURTH YEAR SECOND SEMESTER UNIVERSITY EXAMINATION FOR THE
DEGREE IN BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING (BSME)

EMG 2404
MECHANICS OF MACHINES III

END OF SEMESTER EXAMINATIONS

SERIES: DECEMBER, 2013

TIME: 2 HOURS

INSTRUCTION TO CANDIDATES

1. You should have the following for this examination:-
   - Answer Booklet
   - Scientific Calculator
   - Mathematical Table/Pocket Calculator

2. This paper consists of **FIVE** questions.
3. Answer Question **ONE** is **COMPULSORY** and any other **TWO** Questions.
4. Maximum marks for each part of Question are as shown.
5. This paper consists of **SIX** printed pages.

Question ONE (Compulsory)

(a)   Differentiate between:

(i)   A machine and mechanism
(ii)   A higher and lower knematic pair
(iii)   Kinematic inversion and kinematic diagram

(6 marks)

(b)   (i)   The majority of 4 link mechanisms fall into one of the following two classes
                 namely, the four bar linkage mechanism and the slider-crank mechanism. Explain

the function of a slider crank mechanism and with the aid of a well labeled diagram describe one application of a slider crank mechanism. **(3 marks)**

(ii) The offset slider-crank mechanism in Figure Q1(b) is driven by a rotating crank 2. Suppose AO = 1inch, BA = 2.5 inches and CB = 7 inches, write down the loop closure equation and thus solve for the position of the slider 4 as a function of Θ_2. **(6 marks)**
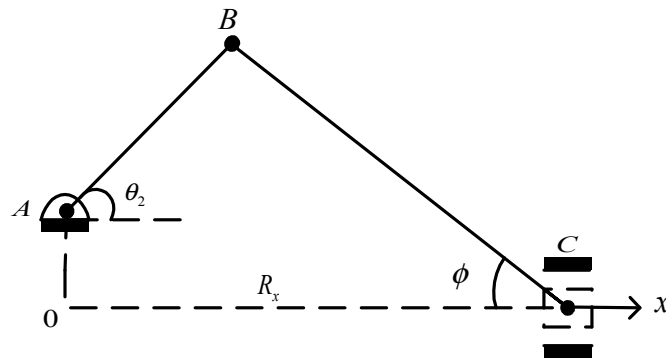

Fig. Q1(b)

(c) (i) With the aid of well labeled diagram differentiate between the following types of mechanisms:
- Crank-rocker mechanism
- Double crank mechanism

(4 marks)

(ii) Consider a four bar linkage mechanism whose links are drawn as position vectors which form a vector loop as shown in Figure Q.1(c). Show that Freudeinstein's equation which relates the input to the output angles as function of the sizes of the links of the mechanism is given by:

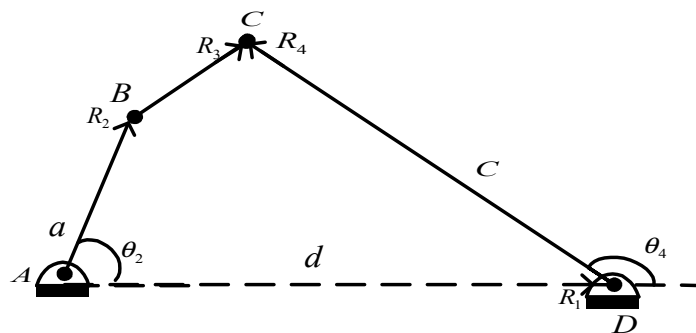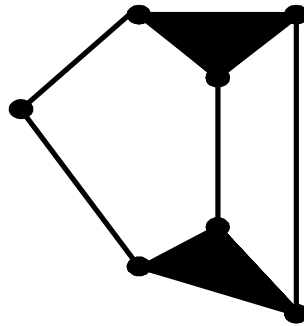$$k_1 \cos\theta_4 - k_2 \cos\theta_2 + k_3 = \cos(\theta_2 - \theta_4)$$

Fig. Q.1(c)

(7 marks)

(iii)   State Grashof's law and its significance in a 4-bar linkage mechanism. **(2 marks)**

(iv)   Using Gruebler's equation, determine whether the following is a kinematic chair or a structure.

(2 marks)

Question TWO

(a)   (i)   Differentiate between a planar mechanism and a spatial mechanism.   **(1 mark)**

(ii)   Show that a spherical pair reduces the number of degrees of freedom in a spatial mechanism by 3.   **(2 marks)**

(b)   Determine the number of degrees of freedom of the RSSR spatial mechanism spatial mechanism shown in Figure Q2(b).   **(4 marks)**
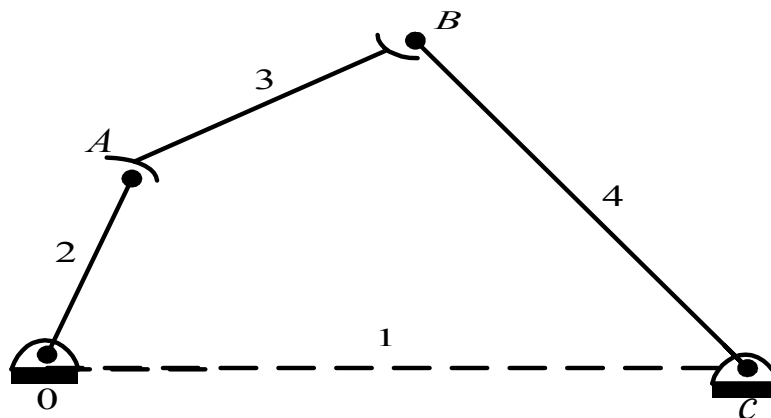

Fig. Q.2 (b)

(c)   Two sliders A and B are connected and constrained so as to move in slots at right angles to each other as shown in Figure Q.2(c). Link AB has a length of 450mm. At the instant $\theta = 30°$, when slider A is moving with a velocity of 0.6m/s and an acceleration of 1.2m/s² in the direction shown. Using the vector method, calculate the velocity and acceleration of slider B at the instant and the angular velocity and acceleration of link AB.
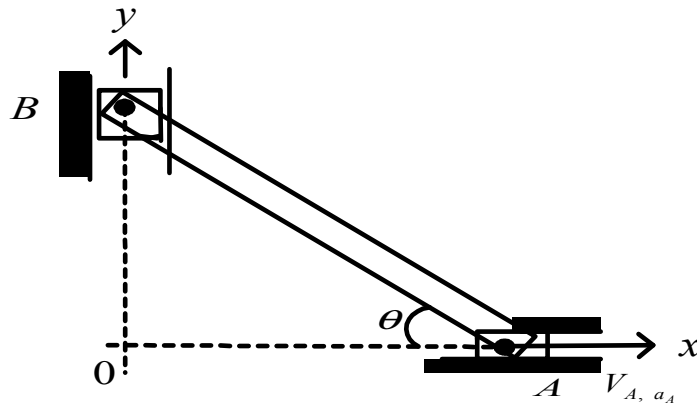

Fig. Q.2(c)

(13 marks)

Question THREE

(a)   (i)   Describe Hooke's join and give an example of where at finds application.

(3 marks)

(ii)   For the single Hooke's joint shown in Figure Q.3(a) show that the ratio of the angular speed of the output shaft ω_B to that of the input shaft, ω_A, is given

$$\frac{\omega_B}{\omega_A} = \frac{\cos \delta}{1 - \sin^2 \delta \cos^2 \alpha}$$
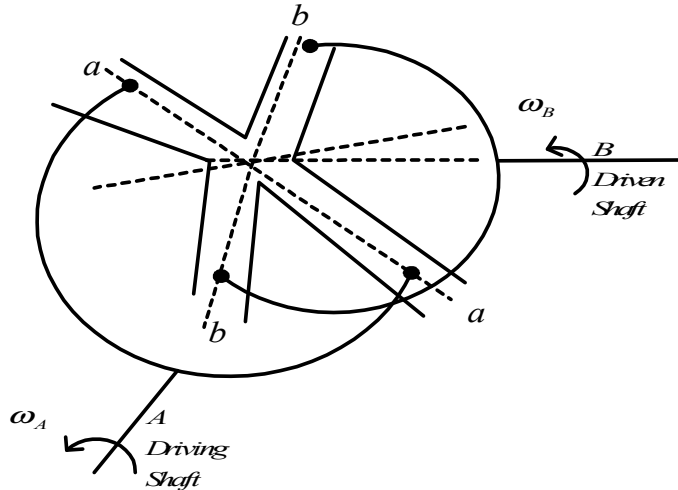
by: **(5 marks)**

Fig. Q.3(a)

(iii)   Also show that the maximum angular acceleration of the output shaft occurs when:

$$\cos 2\alpha = \frac{2\sin^2\delta}{2-\sin^2\delta}$$

(4 marks)

(b)   A Hooke's joint is used to connect two non parallel intersecting shafts whose axes are inclined at 30°. The driving shaft runs at a uniform speed of 250rpm and the driven shaft carries a rotor of I = 1.25kgm². Find the torque on the driving shaft due to the acceleration of the driven shaft at the instant when the acceleration is a maximum.

(4 marks)

(c)   Design a 4 – bar linkage mechanism to co-ordinator rotation of two shafts whose input and output angles are given in the table, and the length of fixed link is to be 300mm. Also check whether the linkage will operate smoothly within the range.

Input Angle	Output Angle
30°	15°
45°	40
60°	
	65

(4 marks)

Question FOUR

(a)   With the help of sketches, describe the following cam follower configurations noting the disadvantages of each:

(i)   Knife-edge follower
(ii)   Roller follower
(iii)   Flat faced follower

(4 marks)

(b)   (i)   Differentiate between cam synthesis an analysis as used in cams.   **(1 mark)**

        (ii)   With the help of a well labeled diagram, describe the main features in cam
                homendature.   **(5 marks)**

(c)   A straight ended cam has both sides tangential to the base circle which is 25mm   radius
        and the total angle of action is 120º. A lift of 10mm is given to a roller 20mm diameter,
        the center of which moves along a straight line passing through the axis of the cam.   The
        camshaft has a speed of 240rev/min. Determine;

        (i)   The radius of the nose arc
        (ii)   The speed of the roller center when the roller is in contact with the cam at the end
                of one of straight flanks adjacent to the nose
        (iii)   The greatest acceleration of the roller center.

(10 marks)

Question FIVE

(a)   Differentiate between the following terms and applied to cams:

        (i)   Rise
        (ii)   Dwell
        (iii)   Return

(3 marks)

(b)   Design a cam to give a swinging link with a roller follower a uniform angular velocity
        about a pivot during its rise and fall. Use the following data; shaft diameter = 10mm,
        base circle diameter = 23mm, roller diameter = 7mm, position of the swinging link pivot
        from the can center = (30mm, 15mm) and the total angular movement of the swinging
        link = 30º. The rotation of the cam is clockwise and there is no eccentricity between the
        center lines of the roller follower and the cam.   **(17 marks)**