ELIZADE UNIVERSITY, ILARA-MOKIN, ONDO STATE

DEPARTMENT OF MECHANICAL ENGINEERING

MEE 303: THEORY OF MACHINES – Exam 1st Semester: Mon. 3rd April 2017

INSTRUCTIONS:

a) Answer **Question 3 or Question 4 and any other four questions**
b) Make clear and properly labeled sketches where required
c) You can use either graphical or analytical solution where relevant
d) For graphical solutions, make neat properly scaled diagrams
e) For calculations, you are advised to first state the steps you would use to solve the problem

Question 1

i. What are the key objectives of the study of 'Theory of Machines'? What are the limitations of the subject? Why is it sometimes called 'Mechanics of Machines'?
ii. Compare the analytical and graphical methods of solving problems of mechanisms stating the advantages and disadvantages of each method
iii. Define relative velocity and relative acceleration for links in a mechanism. Use appropriate sketches to illustrate these parameters
iv. Write equations for conservation of momentum in solving plane problems of dynamics. Explain how these equations are applied to the case of a crank-slider mechanism
v. Define torque in a mechanism. Where can torque occur in a four-bar linkage?
vi. Sketch a slider mechanism in which the link carrying the slider can rotate about the pivot point. State all the components of acceleration for this link
vii. Draw fully *labeled FBD's* that would be used to solve the four-bar linkage in Figure 1 below by superposition method. *Note: **Only the FBD's** are required; no need to solve the problem. Your diagrams should show all the external forces and torque(s) and reactions at the bearings.*

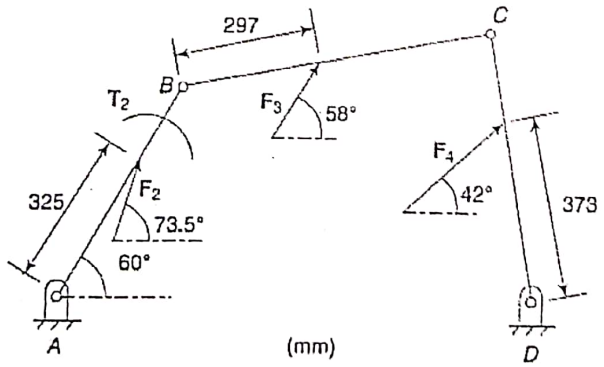

Figure 1

Question 2

Determine the required input torque T_1 on link AB for the static equilibrium of the four bar mechanism shown in Figure 2 below. Input forces P_E and P_F acting at E and F have magnitudes of 50 N and 75 N respectively. Force P_E acts in the horizontal direction. Link lengths are AB=30 cm, BC=40 cm, CD=50 cm, and the fixed link AD=75 cm. Also CE=15cm and CF= 20cm. Use either graphical or analytical method.

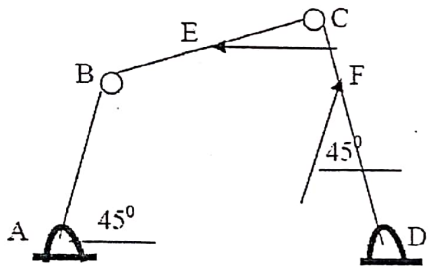

Figure 2

*Question 3

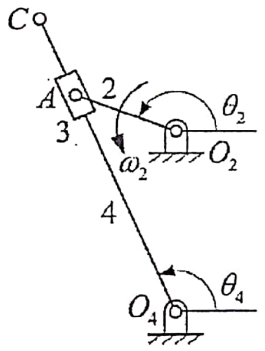

Figure 3

Figure 3 above shows a quick-return mechanism in which the input link O_2A rotates ccw with constant angular velocity $\omega_2 = 10$ rad/s. The dimensions of the links are $O_2A = 3$ cm, $O_2O_4 = 5$ cm, $O_4C = 9$ cm and the input angle in the position shown is $\theta_2 = 160°$.

(i) Determine the velocity $\mathbf{v}_c$ of point C. Use analytical or graphical method.

(ii) The components of acceleration of slider at A can be written as:

$$\mathbf{a}^n_{A_2} + \mathbf{a}^t_{A_2} = \mathbf{a}^n_{A_4} + \mathbf{a}^t_{A_4} + \mathbf{a}^n_{A_2A_4} + \mathbf{a}^t_{A_2A_4} + \mathbf{a}^c_{A_2A_4}$$

iii. Identify (i.e. name) these components. Note: the superscripts are in standard notations.

iv. ***Sketch*** (do not draw to scale) the acceleration polygon.

***Question 4**

The four-bar linkage of Figure 4 below has a constant input angular velocity $\omega_1 = 200$ rad/s clockwise. This produces the following accelerations:

- $a_{G2} = 690$ at 298^o m/s^2, $\alpha_2 = 2670$ $rad/s^2 ccw$,
- $a_{G3} = 292$ at 294^o m/s^2, $\alpha_3 = 6940$ $rad/s^2 cw$ *(subscripts refer to the link numbers)*

Coupler link 2 has mass = 0.78 kg and mass moment of inertia about center of mass G_2 = 3000 kg-mm^2. Follower link 3 has mass = 0.65 kg and mass moment of inertia about its center of mass G_3 = 200 kg-mm^2. (i) Draw FBDs and (ii) Determine all bearing forces and instantaneous input torque T_1 by graphical or analytical method (or by a combination of them)

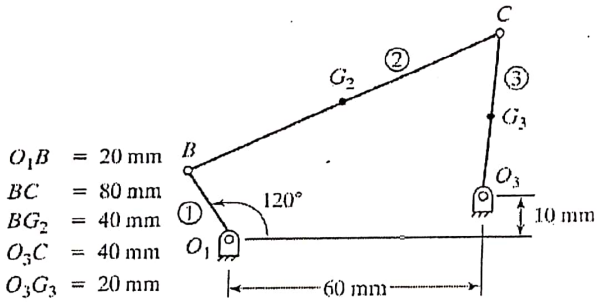

Figure 4

Question 5

i. Sketch and label an open belt drive which has an idler pulley showing the directions of rotation of the pulleys and the relative tensions (tight or slack) in the belt.What is the main advantage of an idler pulley?

ii. Sketch and label a cross belt drive showing the directions of rotation of the pulleys and the relative tensions (tight or slack) in the belt. What is the main difference between a flat and a cross belt?

iii. Sketch and label the cross-section of a vee-belt assembly with its associated pulley indicating places where friction forces will act

iv. Sketch a cone pulley system in cross-section view and explain its use in machines

v. By means of simple geometry, derive an expression for the total length of an open belt drive using approximation for small angles where relevant. Use Figure 5 below as guide

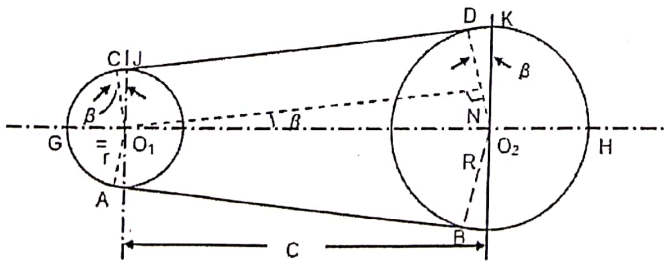

Figure 5

Question 6

(i) An open belt drive has two pulleys having diameters 1.2 m and 0.5 m. The pulley shafts are parallel to each other with axes 4 m apart. The mass of the belt is 1 kg per metre length. The tension is not allowed to exceed 2000 N. The larger pulley is the driving pulley and it rotates at 200 rpm. The speed of the driven pulley is 450 rpm due to the belt slip. The coefficient of friction is 0.3. Determine (a) the power transmitted and (b) power lost in friction. Draw a properly labelled diagram of this assembly.

(ii) From first principles, show that the tension T_C due to centrifugal forces in a belt drive is given by $T_C = mv^2$, where m is the mass of the belt per unit length and v is the drive speed.

(iii) Explain how centrifugal tension affects power transmitted and write an expression (do not derive it) that characterizes this effect

Question 7

(a) With the aid of appropriate sketches, distinguish between a simple gear transmission and a compound gear transmission.

(b) Consider 2 sets of gear trains consisting of 4 gears 1, 2. 3 and 4 as follows. The first set is a simple gear assembly, while the second has one pair of gears in compound assembly. The compound gear is shown in Figure 6 below. Let N_1, N_2, N_3, N_4 be speed in rpm of gears 1, 2, 3, 4 resp. and t_1, t_2, t_3, t_4 be number of teeth of respective gears 1, 2, 3, 4. Draw sketches of the simple gear assembly. Calculate the gear ratio for each assembly. What is the main difference between the results?

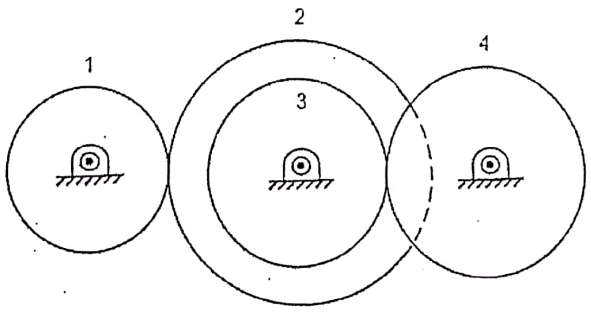

Figure 6