ELIZADE UNIVERSITY, ILARA-MOKIN,
ONDO STATE, NIGERIA

DEPARTMENT OF MECHANICAL ENGINEERING

FIRST SEMESTER EXAMINATIONS

2019/2020 ACADEMIC SESSION

HOD'S SIGNATURE

COURSE: MEE 303 – Theory of Machines (2 Units)

CLASS: 300 Level Mechanical & Automotive Engineering

TIME ALLOWED: 2 Hours: 30 Min

INSTRUCTIONS: Answer Questions 1 and any other **three** questions. Only short answers are required for each item in Question 1.

Date: February, 2020

Question 1

a) Distinguish between kinematics and dynamics of a mechanism.
b) State two examples of objects which can be modeled as a four-bar mechanism.
c) Sketch a quick-return mechanism.
d) Explain the use of Newton's laws of motion in solving problems of the dynamics of mechanisms
e) Compare analytical solution with graphical method in the solution of dynamics of mechanisms.
f) What are the components of acceleration to be accounted for in the dynamics of a crank-slider mechanism?
g) Define torque in the dynamics of mechanisms and sketch the graph of its variation in the output motion of a machine
h) State the formulae for the conservation of momentum for planar mechanism in vector form and in 2D rectangular coordinate system
i) What is a rigid body and what are the parameters involved in rigid body motion?
j) What is a 3-force member?
k) Explain how the principle of superposition is used in solving dynamics problems of mechanisms. What are the limitations of this method?
l) Use sketches to differentiate between open belt and crossed belt drive
m) What is meant by slip in a belt drive?
n) Write the formula for power transmission by a vee-belt (name the symbols you use)
o) What are the common types of balancing problems?
p) State the analytical basis for balancing in reciprocating engines.

Question 2

(a) Draw ***fully labeled FBD's*** that would be used to solve the four-bar linkage in Figure 1 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.*

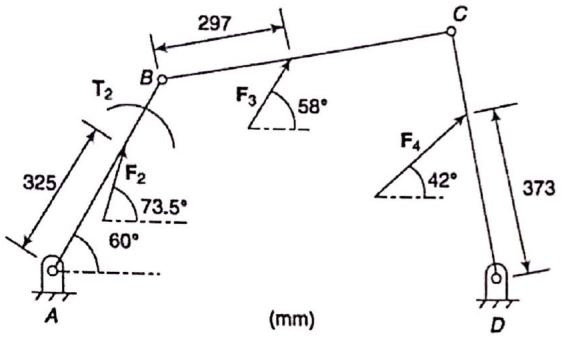

Figure 1

(b) State the steps you would use to determine the input torque T_2 in the mechanism of Figure 1 using the principle of superposition (***Note: only the steps are required not the full calculation***).

Question 3

a) State D'Alembert's principle for dynamic analysis of a mechanism. Write an expression for it, identifying all the notations you use.

b) Draw the **FBD's only** for the dynamic analysis of the slider-crank mechanism shown in Figure 2. Show all the forces and acceleration components. Input torque T_1 is applied on crank O_1B, and G_1, G_2 are the centers of gravity of the respective links.

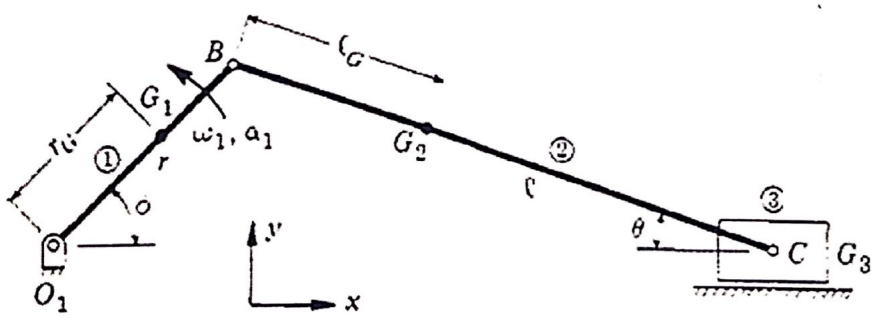

Figure 2

c) For the crank- connecting rod mechanism shown in Figure 3: OA= 10 cm, AB= 30 cm, AC= 10 cm. Its single degree of freedom coordinate is angle θ. If ω=30 rad/sec and α =100 rad/s^2. Find ω_{AB} and v_B at θ = 30°. Use either analytical or graphical method.

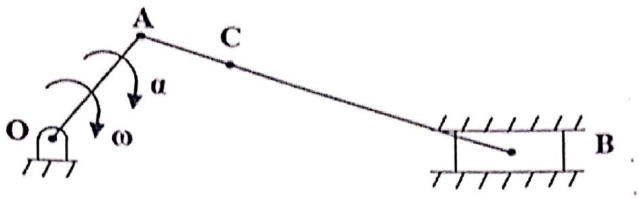

Figure 3

Question 4

(a) 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. Do the following:

(i) Draw a properly labelled diagram of this assembly,

(ii) Determine the power transmitted, and

(iii) Calculate the power lost due to friction.

(b) 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.

Question 5

(a) Referring to Figure 4, distinguish between a simple gear transmission and a compound gear transmission.

(b) Consider the two sets of gear trains consisting of 4 gears 1, 2. 3 and 4 as shown in Figure 4. The first set is a simple gear assembly, while the second has one pair of gears in compound assembly. Let N_1, N_2, N_3, N_4 be speed in rpm of gears 1, 2, 3, 4 respectively and T_1, T_2, T_3, T_4 be number of teeth of the respective gears 1, 2, 3, 4.

Calculate the gear ratio for each assembly and explain the main difference between the results.

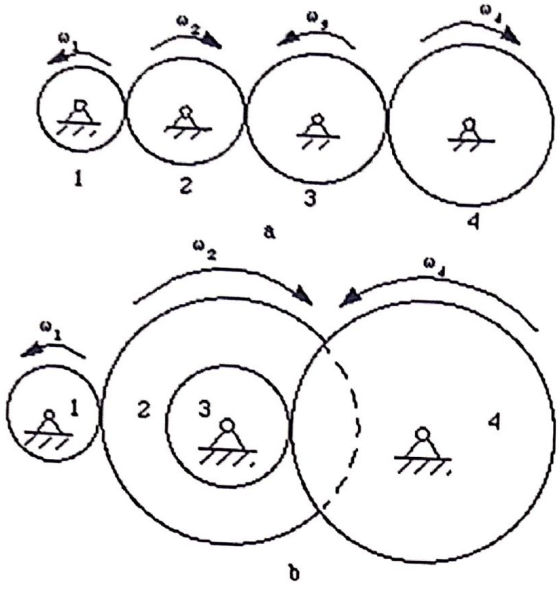

Figure 4

Question 6

(a) Figure 5 illustrates relative motion of two points A, B on a link AB

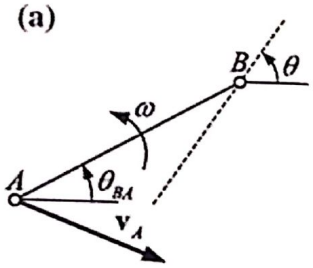

Figure 5

Do the following:

i. Draw the figure and explain the quantities shown to represent the relative motion.

ii. Assume link AB is rotating at angular velocity ω (counterclockwise), and that we are given velocity $\mathbf{v}_A$ of point A, and the direction of velocity $\mathbf{v}_B$ of point B, explain how $\mathbf{v}_B$ can be determined by either a vector **or** graphical method.

(b) The components of acceleration of the slider in a quick-return mechanism can be written as:

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

Sketch the mechanism and name these acceleration components. Note: the subscripts and superscripts are in standard class notations.