FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGERIA
SCHOOL OF ELECTRICAL ENGINEERING AND TECHNOLOGY
DEPARTMENT OF MECHATRONICS ENGINEERING
FIRST SEMESTER 2018/2019 B.Eng. DEGREEEXAMINATION
COURSE: MCE 413 ROBOTICS
INSTRUCTION: Please Attempt all questions
TIME ALLOWED:3 Hours.

Question One (Robot kinematics and position analysis). (30 Marks).

a). As a Mechatronics Engineering student that has taken a course in Robotics, you are rotating a frame along X,Y and Z axis respectively, using appropriate diagrams, show the Rotations ROT($\hat{X}$,30) , ROT($\hat{Y}$, -30), ROT ($\hat{Z}$,30) of the frame subject to the following conditions:

i. With respect to each other. **(5 Marks)**
ii. Each With respect to the universal coordinate system. **(5 Marks)**

b).

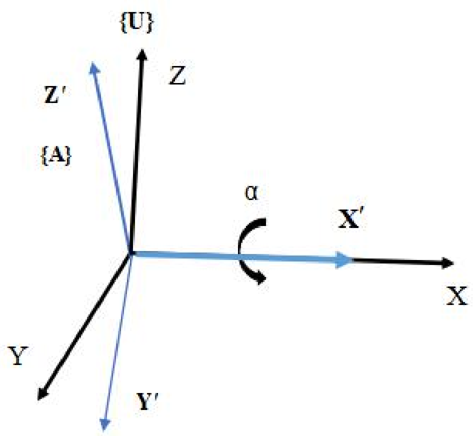

Figure 1

Figure 1 represents the rotation of frame {A} along X axis with respect to universal coordinate System {U}.

i. With reference to Figure 1 which represents the rotation of a frame {A} along X axis with respect to universal coordinate System {U}, you are expected to represent the rotation of {A} along Y and Z with respect to {U} using appropriate diagrams. **(5 Marks)**

ii. Represent in matrix form ROT ($\hat{X}$,α) , ROT ($\hat{Y}$,β) and ROT ($\hat{Z}$, γ) of frame {A} in fig.1 above , if $\alpha = 35°$, $\beta = 35°$,$\gamma = -35°$. **(5 Marks)**

c). A set of students are working on a bipedal Robot in which a joint was programmed to make the rotations Rot(Z,25) ,Rot(X,25),Rot(Z,-50) respectively, you were to help these students to :

i. Draw these rotations with respect to each other **(5 Marks)**
ii. Represent these rotations in Matrix Form **(5 Marks)**

Question Two (Denavit-Hartenberg Representations). (30marks).

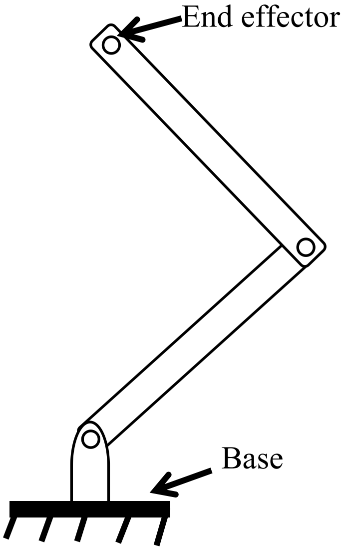

Figure 2

Figure 2 represents a 2 DOF serial manipulator. Using the Denavit-Hartenberg Notations,

a). Find the position and orientation of the End effector with respect to the Base in Figure 2. **(15 Marks)**

b). With the aid of diagrams illustrate each transformation (rotations and translations) from the initial to the final position and orientation of each joints in figure 2. **(15 Marks)**

Question Three (Dynamic Analysis). (20 Marks).

a). Distinguish between the terms kinematics and dynamics of Robots. **(4 Marks)**

b). Having taken MCE 413, you are expected to state the two methods used to describe the dynamics of robots. In addition explain using nothing less than six sentences any of the two methods. . **(4 Marks)**

c). Given a 1D point mass with a spring and damper system as shown in figure 3,

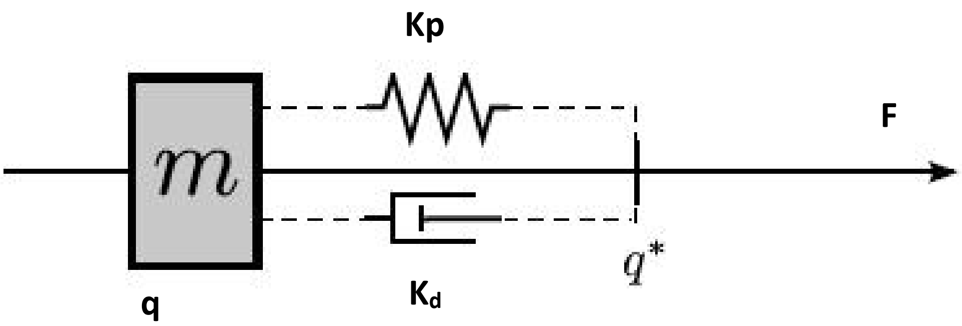

Figure 3

i. Derive the simplified dynamics for the system given. **(6 Marks)**

ii. Assuming $\boldsymbol{q(t) = a + be^{\omega t}}$, the solution for the differential equation derived in (c)i above is

$$\omega = \frac{-K_d \pm \sqrt{K_d^2 - 4mK_p}}{2m}$$

Under what conditions can you say that the system is over-damped, critically damped and under-damped?
Hint: The conditions should be represented by the relationship between
K_d *and* $\sqrt{4mK_p}$ **(6 Marks)**

Question Four (Overview of Robots and Components). (20 Marks).

a). List the basic components of a robot known to you defining each briefly. **(4 Marks)**

b). Compare propioceptive sensors to exteroceptive sensors. **(3 Marks)**

c). Mention the types of Robot joints you know and movements they perform. **(4 Marks)**

d). What is the basic difference between a Sensor and an Actuator. **(3 Marks)**

e). Explain briefly the following terms associated with of Robotics.

i. Robot-degree-of freedom
ii. Robot Workspace
iii. Robot Mobility **(6 Marks)**