# BIRLA INSTITUTE OF TECHNOLOGY
MESRA – 835215, RANCHI, INDIA

UG

Name: …… Roll No.: ……..

Branch: …… Signature of Invigilator: ……

Semester: VIth Date: 27/04/2022 (MORNING)

Subject with Code: **ME307 ROBOTICS ENGINEERING**

| Marks Obtained | Section A (30) | Section B (20) | Total Marks (50) |
|---|---|---|---|
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**INSTRUCTION TO CANDIDATE**

1. The booklet (question paper cum answer sheet) consists of two sections. First section consists of MCQs of 30 marks. Candidates may mark the correct answer in the space provided / may also write answers in the answer sheet provided. The Second section of question paper consists of subjective questions of 20 marks. The candidates may write the answers for these questions in the answer sheets provided with the question booklet.
2. The booklet will be distributed to the candidates before 05 minutes of the examination. **Candidates should write their roll no. in each page of the booklet.**
3. Place the Student ID card, Registration Slip and No Dues Clearance (if applicable) on your desk. All the entries on the cover page must be filled at the specified space.
4. Carrying or using of mobile phone / any electronic gadgets (except regular scientific calculator)/chits are strictly prohibited inside the examination hall as it comes under the category of unfair means.
5. No candidate should be allowed to enter the examination hall later than 10 minutes after the commencement of examination. Candidates are not allowed to go out of the examination hall/room during the first 30 minutes and last 10 minutes of the examination.
6. Write on both side of the leaf and use pens with same ink.
7. The medium of examination is English. Answer book written in language other than English is liable to be rejected.
8. All attached sheets such as graph papers, drawing sheets etc. should be properly folded to the size of the answer book and tagged with the answer book by the candidate at least 05 minutes before the end of examination.
9. The door of examination hall will be closed 10 minutes before the end of examination. Do not leave the examination hall until the invigilators instruct you to do so.
10. Always maintain the highest level of integrity. Remember you are a BITian.
11. Candidates need to **submit the question paper cum answer sheets before leaving the examination hall**.

**BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI**
**(END SEMESTER EXAMINATION)**

**CLASS: UG** **SEMESTER : VI**
**BRANCH:ME** **SESSION : SP/22**

**SUBJECT: ME307 Robotics Engineering (Set A)**

**TIME: 2 Hours** **FULL MARKS: 50**

**INSTRUCTIONS:**
**1. Attempt all questions.**
**2. The question paper contains 15 MCQ questions (1-15) each of 2 marks and 5 descriptive questions (16-20) each of 4 marks.**
**3. The missing data, if any, may be assumed suitably.**
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
**5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.**

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1. **What does the last column of the homogeneous transformation matrix $\boldsymbol{{}^{A}_{B}T}$ represents?**
   a. Eigen vector of the rotational matrix
   b. Axis of rotation
   c. Vector joining origins of {A} and {B} with the direction heading {B} to {A}
   d. Vector joining origins of {A} and {B} with the direction heading {A} to {B}
2. **Two consecutive rotation commute when we accomplish**
   a. Euler angle rotation
   b. Fixed angle rotation
   c. Very large angle of rotation using Euler or fixed angle rotation
   d. Infinitesimally small angle of rotation using Euler or fixed angle rotation
3. **What kind of transformation the below given matrix represents?**

$$ {}^{A}_{B}\boldsymbol{R} = \begin{bmatrix} \boldsymbol{\cos\theta} & \boldsymbol{0} & \boldsymbol{\sin\theta} \\ \boldsymbol{0} & \boldsymbol{1} & \boldsymbol{0} \\ \boldsymbol{-\sin\theta} & \boldsymbol{0} & \boldsymbol{\cos\theta} \end{bmatrix} $$

   a. Frame B rotated with respect to frame A about x-axis in anticlockwise
   b. Frame B rotated with respect to frame A about x-axis in clockwise
   c. Frame B rotated with respect to frame A about y-axis in anticlockwise
   d. Frame B rotated with respect to frame A about z-axis in anticlockwise

4. **The determinant of rotation matrix**
   a. =0
   b. =1
   c. depends upon angle of rotation
   d. depends upon axis of rotation

5. **What kind of transformation the below given matrix represents?**

$$ {}^{A}_{B}\boldsymbol{R} = \begin{bmatrix} \boldsymbol{1} & \boldsymbol{0} & \boldsymbol{0} \\ \boldsymbol{0} & \boldsymbol{\cos\alpha} & \boldsymbol{-\sin\alpha} \\ \boldsymbol{0} & \boldsymbol{\sin\alpha} & \boldsymbol{\cos\alpha} \end{bmatrix} \begin{bmatrix} \boldsymbol{\cos\theta} & \boldsymbol{-\sin\theta} & \boldsymbol{0} \\ \boldsymbol{\sin\theta} & \boldsymbol{\cos\theta} & \boldsymbol{0} \\ \boldsymbol{0} & \boldsymbol{0} & \boldsymbol{1} \end{bmatrix} $$

   a. Frame B with respect to frame A, rotated‘ $\boldsymbol{\alpha}$ ’angle about x-axis first then ‘$\boldsymbol{\theta}$’ angle about the rotated z-axis, in anticlockwise.
   b. Frame B with respect to frame A, rotated‘ $\boldsymbol{\alpha}$ ’ angle about x-axis first then ‘$\boldsymbol{\theta}$’ angle the original about z-axis in anticlockwise.
   c. Frame B with respect to frame A, rotated‘ $\boldsymbol{\theta}$ ’angle about z-axis first then ‘$\boldsymbol{\alpha}$’ angle about the rotated x-axis, in anticlockwise.

d. Frame B with respect to frame A, rotated‘ $\boldsymbol{\theta}$ ’angle about z-axis first then ‘$\boldsymbol{\alpha}$’ angle about the original x-axis, in anticlockwise.

**6. What kind of transformation the below given homogeneous matrix represents?**

$$ {}^{A}_{B}\boldsymbol{R} = \begin{bmatrix} \cos\theta & -\sin\theta & 0 & 2 \\ \sin\theta & \cos\theta & 0 & 4 \\ 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

a. Frame B origin is translated to (2,4,1) with respect to frame A, and rotated ‘θ’angle about z-axis of the frame A in anticlockwise.
b. Frame A origin is translated to (2,4,1) with respect to frame B, and rotated‘θ’angle about z-axis of the frame B in anticlockwise.
c. Frame A with respect to frame B, origin translated to (-2,-4,-1) and rotated‘ θ ’angle about y-axis
d. Frame A with respect to frame B, origin translated to (2,4,1) and rotated‘ θ ’angle about x-axis

**7. In fixed angle rotation pitch is**
a. rotation about x-axis
b. rotation about y-axis
c. rotation about z-axis
d. consecutive rotation about x then y, and finally z.

**8. In D-H parameter $\alpha_i$ is**
a. angle between $X_i$ and $X_{i+1}$ measured about $Z_i$
b. angle between $X_{i-1}$ and $X_i$ measured about $Z_i$
c. angle between $Z_{i-1}$ and $Z_i$ measured about $X_i$
d. angle between $Z_i$ and $Z_{i+1}$ measured about $X_i$

**9. The space where is end effector can reach every point from all orientation is called**
a. Reachable workspace
b. manipulators workspace
c. dexterous workspace
d. none

**10. For a robot unit to be considered a functional industrial robot, typically, how many degrees of freedom would the robot have?**
a. three
b. four
c. eight
d. six

**11. Forward kinematic means…….**
a. Joint space to Cartesian space mapping
b. Cartesian space to Joint space mapping
c. Cartesian space to Cartesian space mapping
d. Joint space to Joint space mapping

**12. In general, a joint space trajectory planning algorithm is required to have the following features:**
a. the generated trajectories should be not very demanding from a computational viewpoint,
b. the joint positions and velocities should be continuous functions of time (Continuity of accelerations may be imposed, too),
c. both a and b
d. none

**13. The Jacobian in force domain relates external torque/force matrix F and joint torque/force matrix τ as**
a. $\tau = J^T F$
b. $F = J^T \tau$
c. $\tau = J^{-1} F$

d. $F = J^{-1}\tau$

**14. In Newtonian formulation of manipulator dynamics, to include gravity**

a. we accelerate the manipulator upward with acceleration g.
b. we apply force $m_i g$ on $i^{th}$ joint where $m_i$ is the mass of $i^{th}$ link.
c. we apply Mg on the end-effector where M is the mass of the manipulator
d. we apply Mg on the base link where M is the mass of the manipulator

**15. Chose the correct statement(s)**

a. Number of links in serial robot = no. of DOF
b. Number of joints in serial robot = no. of DOF
c. Number of joints in parallel robot = no. of DOF
d. Number of actuators in parallel robot = no. of DOF

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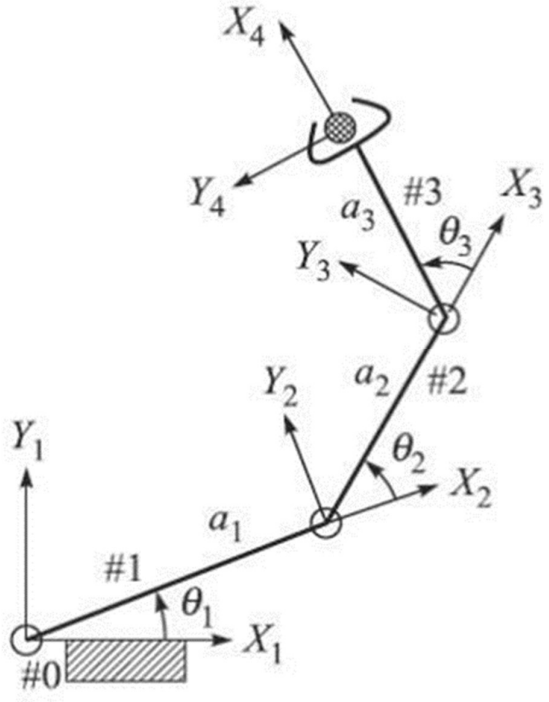
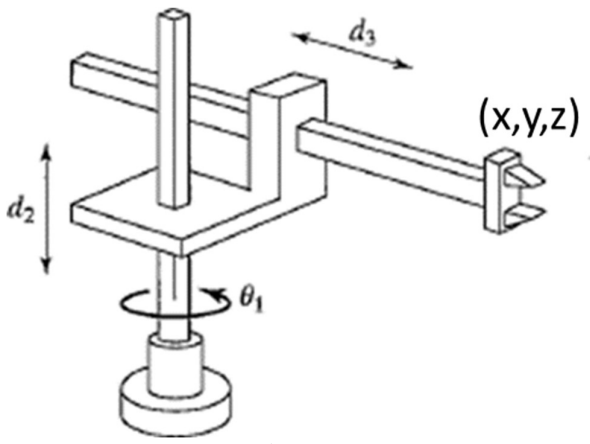
| Q.16 | For given manipulator (see Fig. Q.16), assign appropriate frames for the Denavit-Hartenberg (DH) representation. Fill out the DH parameters table and write an equation in terms of a matrices that shows how ${}^0_3T$ can be calculated.   Fig. Q.16 | [4] |
| Q.17 | Derive the inverse kinematics of thee arm shown in Fig. Q.17.   Fig. Q.17 | [4] |
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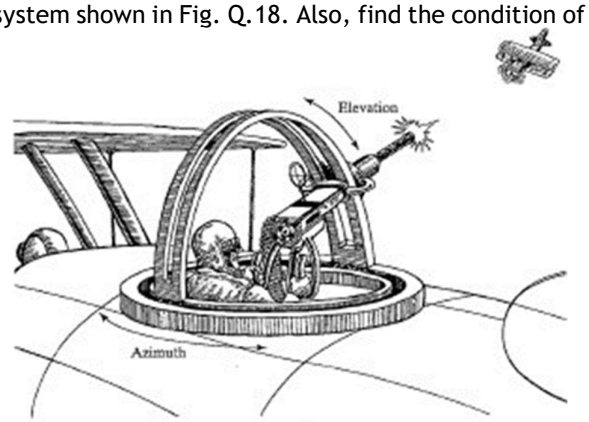
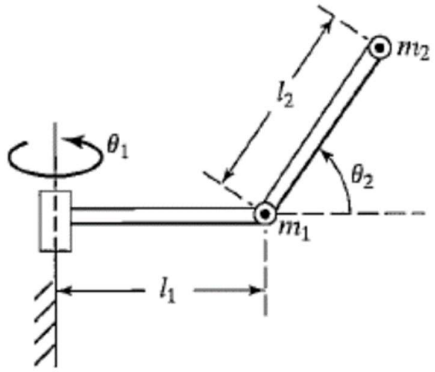
| Q.18 | Find the Jacobian of the system shown in Fig. Q.18. Also, find the condition of singularity for the same. | [4] |
| |  <br>Fig. Q.18: A World War I biplane with a pilot and a rear gunner. | |
| Q.19 | Derive Euler-Lagrange equation of motion of the 2DOF manipulator shown in Fig. Q.19. Assume the mass of the links are concentrated at the end of the links and connected by massless rods. | [4] |
| |  <br>Fig. Q.19 | |
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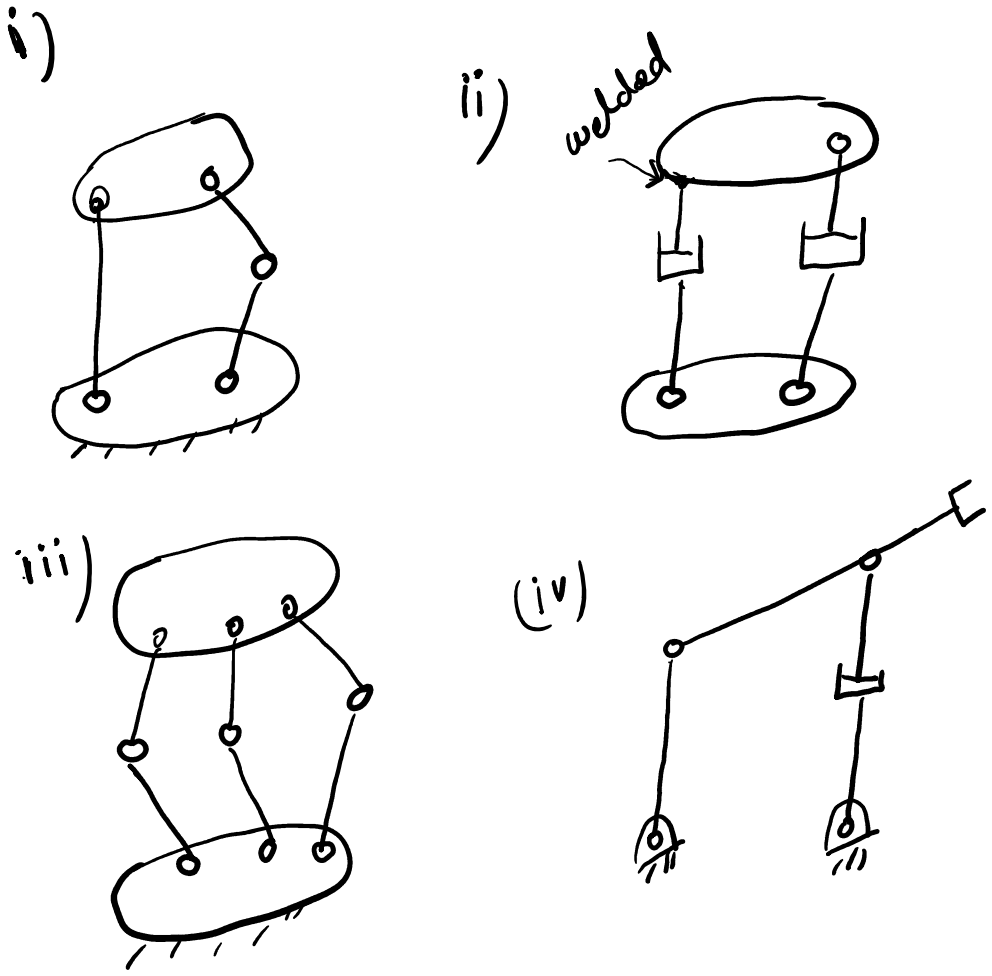
| Q.20(a) | Do nomenclature of the planar manipulators shown below<br>  | [2] |
| Q.20(b) | Describe various industrial applications of robotics | [2] |
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**:::::27/04/2022:::::**