Total No. of Questions : 8]

SEAT No. :

PD4443

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[6403]-248

T.E. (Robotics and Automation)

INDUSTRIAL ROBOTICS & MATERIAL HANDLING SYSTEMS

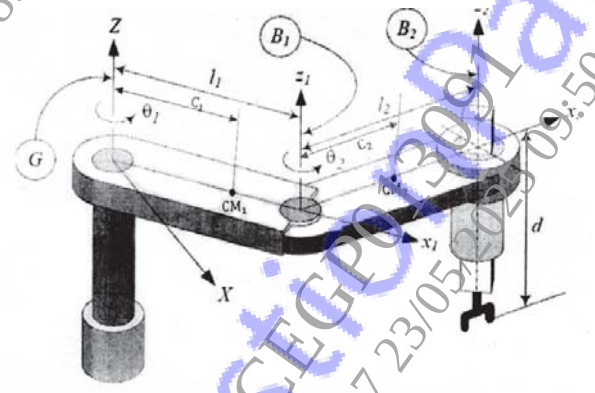
(2019 Pattern) (Semester - V) (311505AIII) (Elective - I)

Time : 2½ Hours] *[Max. Marks : 70*

Instructions to the candidates:

1) ***Answer Q.1 or Q.2, Q.3 or Q.4, Q.5 or Q.6, and Q.7 or Q.8.***
2) ***Figures to the right indicates full marks.***
3) ***Neat diagrams must be drawn wherever necessary.***
4) ***Assume suitable data, if necessary.***
5) ***Use of logarithmic table, slide rule and electronic pocket calculator is allowed.***

Q1) a) Consider a SCARA used for Pick and Place operation as shown in the figure below: **[9]**



Considering along the Z, and Z_1 axes there has consolidated motion along (X, Y) and (X_2, Y_2) the given system . The force matrix by using Newton- Euler Equation with respective to G, B_1 and B_2 frame is given as:

$$^0F_0 = m_1\begin{bmatrix} a_{1x} \\ a_{1y} \\ a_3 \end{bmatrix} + m_2\begin{bmatrix} a_{2x} \\ a_{2y} \\ a_3 \end{bmatrix} - \begin{bmatrix} 0 \\ 0 \\ (m_1+m_2+m_3+m_0)g \end{bmatrix}$$

$$^0F_1 = m_2\begin{bmatrix} a_{2x} \\ a_{2y} \\ a_3 \end{bmatrix} - \begin{bmatrix} 0 \\ 0 \\ (m_2+m_3+m_0)g \end{bmatrix}$$

$$^0F_2 = (m_3+m_0)\,a_3\hat{k} + \begin{bmatrix} 0 \\ 0 \\ (m_3+m_0)g \end{bmatrix}$$

P.T.O.

Where, m_1, m_2 are masses of $(link)_1$ and $(link)_2$ while, m_3 is mass of gripper while m_0 is mass of payload. The centre of mass CM_1 and CM_2 is located at geometric centres of the link.Table: 1 gives the values of maximum angular movements by the links possible, the lengths of links and the mass of the link.

Table:1 Parameter of the links

Length of links (meters)		Maximum angular movements (Deg.)		Mass (kg)	
l_1	2	θ_1	40	m_1	10
l_2	1	θ_2	140	m_2	5
d	2.5	–	–	m_3	3
–	–	–	–	m_0	?

Determine:

i) The accelerations a_{1x}, a_{1y}, a_{2x} and a_{2y}.

ii) The payload capacity of the system neglecting the kinematics of gripper, if the kinematic condition of operation of the links is shown in Table:2 and the acceleration of the gripper along Z_2 as 1m/sec.^{2}

Table:2 kinematics of the links

Angular Velocity (rad./sec)		Angular acceleration (rad./sec^2)		Forces at the joints (N)	
$\dot{\theta}_1$	1	$\ddot{\theta}_1$	0.5	${}^0F_0$	(6.76,13.12,-210.63)
$\dot{\theta}_2$	2.4	$\ddot{\theta}_2$	1	${}^0F_1$	(4.55, 8, -122.53)
–	–	–		${}^0F_2$	(0,0,86.48)

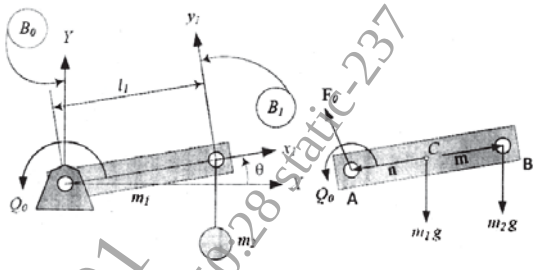
b) Differentiate between an Articulated Robot and Cartesian Robot. **[8]**

OR

Q2) a) A turning uniform beam with a payload at the tip of mass m_2. Figure below illustrates the FBD of the beam. The mass center of the beam is at ${}^1r_1$ **[8]**

$$ {}^1r_1 = \frac{m_1}{m_1+m_2}\begin{bmatrix} l/2 \\ 0 \\ 0 \end{bmatrix} + \frac{m_2}{m_1+m_2}\begin{bmatrix} l \\ 0 \\ 0 \end{bmatrix} $$

$$ = \begin{bmatrix} \frac{m_1+2m_2}{2(m_1+m_2)}l \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} r_x \\ 0 \\ 0 \end{bmatrix} $$



An expression of Force Matrix using Newton-Euler Equation is given by:

${}^0F_0 =$

$$\begin{bmatrix} F_X \\ F_Y \\ F_Z \end{bmatrix} = \begin{bmatrix} -(m_1+m_2)r_x\,(\ddot{\theta}\sin\theta - \dot{\theta}^2\cos\theta) \\ (m_1+m_2)r_x\,(\ddot{\theta}\cos\theta + \dot{\theta}^2\sin\theta) + (m_2+m_1)g \\ 0 \end{bmatrix}$$

Determine maximum payload capacity(m_2) of beam, if the maximum turning angle of the beam is 80º with constant angular acceleration is 0.1 rad/sec.^{2} and angular velocity as 1 rad/sec. resulting in force exertion at joint A at x-axis 5 N and y-axis 66.52 N. The mass of the beam is 4 kg while the length of the beam is 1 meter.

b) What are the general considerations done for selecting a robotic material handling system? **[9]**

Q3) a) If the material and the vacuum end effector has following condition:

m = mass of the object = 120 kg, S= Factor of safety = 2, Z= Number of suction cups= 6, P_u= Applied pressure =0.8 bar = 0.08 MPa, μ= coefficient of friction = 0.7, a= vertical acceleration = 3 m/s^2, F_D= Damping force of each disc= 10 N **[9]**

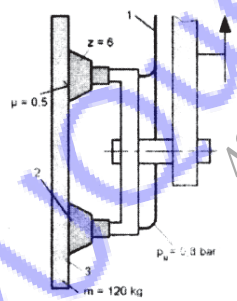


Fig. a)

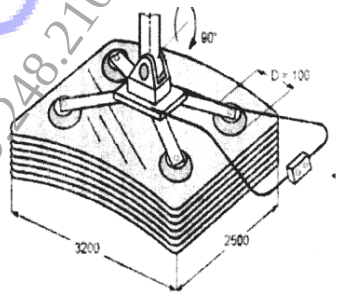


Fig. b)

i) Determine the required cup diameter for the vacuum grippers shown above for steady 90° tilt, as shown in Fig. a)

ii) Determine the gripping force for the vacuum grippers shown above following horizontal tilt if diameter of cup, D= 100 mm, as shown in Fig. b).

b) Write a short note on 'Passive Grippers'. **[9]**

OR

Q4) a) How is the performance of a robot tested? Explain in details various methods with certain case studies. **[9]**

b) Define Electromagnetic Grippers? An electromagnetic gripper has following specification as given below: **[9]**

Specification	Values
No. of coil winding	1000
Current Supply	10 A
Length of coil	1.5 m
Permeability of wire	1.2556629×10^{-6} H/m
Permeability in vacuum	$4\pi \times 10^{-7}$ H/m
Cross section area	0.5 m^2

i) Find the gripping force of the electromagnetic gripper if there are 10 such grippers used.

ii) Check if the gripper can hold the payload of 10kg.

(consider g = 9.81 m/s^2)

Q5) a) Write a short note on any one type of manufacturing robot in details. **[9]**

b) Differentiate between conventional palletizing and robotic palletizing. **[9]**

OR

Q6) a) Explain the principle of operation of Robotic Vision. **[9]**

b) Explain the various types of Painting Robots. **[9]**

Q7) a) Write a short note on 'Climbing Robots'. **[8]**

b) Explain the principle of operation and working of Underwater Robots. **[9]**

OR

Q8) a) Explain various types of 'Medical Robots'. **[8]**

b) Explain the Lee's Algorithm of Obstacle Avoidance. **[9]**

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