QUIZ

Started on	Monday, 31 July 2023, 4:00 PM
State	Finished
Completed on	Monday, 31 July 2023, 5:35 PM
Time taken	1 hour 35 mins
Grade	**17.25** out of 20.00 (**86.25**%)

Question 1

Partially correct

Mark 2.00 out of 3.00

[3 Marks] Basic questions (Please answer with 4 decimal places for all questions) **[HINT: LECTURE 7]**

(I) A robot joint moves from q(0) = 13 (degree)to q(t) = 60 (degree) with a bang-bang trajectory. The constant acceleration of the bang-bang trajectory is a = 6(deg/s^2)

Calculate the switch time (s) (**0.5 Marks**):

t_s= 2.7988

Calculate switch velocity (deg/s) (**0.5 Marks**)

V_s= 16.7929

(**II**) A single joint robot (**revolute**) has a transformation matrix from the base frame {0} to the end-effector frame {1} [**HINT: REFER TO LECTURE 5'S EQUATIONS**]

${}^0T_1$ =

$$\begin{matrix} 0.88 & -0.48 & 0 & 34.23 \\ 0.48 & 0.88 & 0 & 18.7 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{matrix}$$

The origin and z-axis of the {0} frame are O_0= [0 ;0; 0] and Z_0=[0; 0; 1], respectively.

Calculate the translational velocity Jacobian of this robot (i.e., J_v) (**1 Mark**)

-18.7
34.23
0

(III) Decoupling method for inverse kinematic of a 6DOF robot with a spherical joint [HINT: REFER TO LECTURE 5. YOU CAN FIND P AND ${}^0z_6$ FROM THE MATRIX ${}^0T_6$]

The transformation matrix between the base frame {0} and the end-effector frame {6} is:

${}^0T_6$ =

$$\begin{matrix} 0 & -1 & 0 & 11 \\ 0 & 0 & -1 & 8 \\ 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \end{matrix}$$

Calculate the coordinate of the origin of the spherical joint (P_c) if the end effector position (P) can be reached by translating P_c a distance of 16 along ${}^0z_6$ axis. (**1 Mark**)
Do not consider unit for this question.

P_c=

-8
15
11

Your last answer was interpreted as follows: -18.7

Your last answer was interpreted as follows: 34.23

Your last answer was interpreted as follows: 0

Your last answer was interpreted as follows: -8

Your last answer was interpreted as follows: 15

Your last answer was interpreted as follows: 11

Correct answer, well done.
Correct!

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

Incorrect answer.

Incorrect answer.

Incorrect answer.

A correct answer is 2.7988, which can be typed in as follows:

```
2.7988
```

A correct answer is 16.7929, which can be typed in as follows:

```
16.7929
```

A correct answer is -18.7, which can be typed in as follows:

```
-18.7
```

A correct answer is 34.23, which can be typed in as follows:

```
34.23
```

A correct answer is 0.0, which can be typed in as follows:

```
0.0
```

A correct answer is 11.0, which can be typed in as follows:

```
11.0
```

A correct answer is 24.0, which can be typed in as follows:

```
24.0
```

A correct answer is 1.0, which can be typed in as follows:

```
1.0
```

Question 2

Correct

Mark 3.00 out of 3.00

[3Marks] Basic question

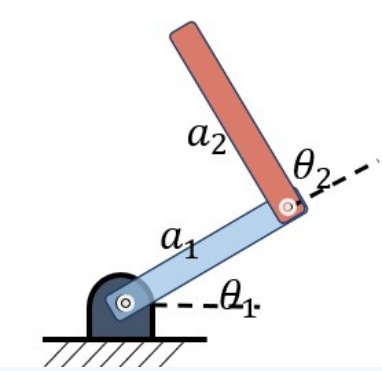
(I) Artificial Potential Field

A single link robot is under a Conic Well Potential: $U_{att,i}(q)=9.5\ |O_i(q)-O_i(q_f)|$ (Nm)

Calculate the absolute value of the attractive force (if the current position and the final position are different) (**0.75Marks**) (Unit: N)

|F|= 9.5

(II) Manipulability [HINT: REFER TO LECTURE 7 SLIDES - MANIPULABILITY EXAMPLE]



Calculate the manipulability of a two-link robot with link lengths of a1 = 1.0 (m); a2 = 0.6 (m) at joint variable of theta1 = 1.0 (rad); theta2 = 0.3 (rad). (*No need to change unit for this question*) (**0.75 Mark**)

Manipulability = |det(J)|= 0.1773

(III) Euler–Lagrange [HINT: REFER TO THE TUTORIAL SLIDES]

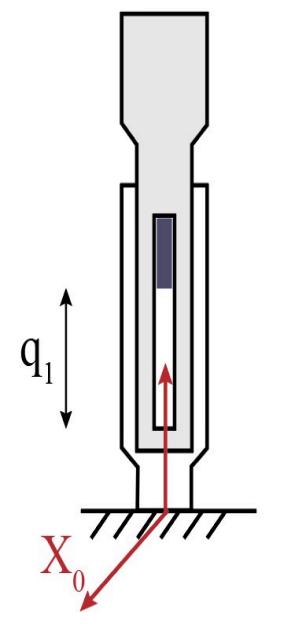


Figure above shows a single prismatic joint robot. The mass of the link is m = 26 (kg), the link displacement is q_1 = 0.6 (m), and the instantaneous velocity is v=0.03 (m/s).

Calculate the inertia matrix (only one component for a single joint robot) (**0.5 Marks**) (unit: kg)

D11 = 26

Write the Lagrangian of this Robot: (**0.5 Marks**) (unit: J = Nm)

L = K-P = -152.868

Calculate the gravity loading (only one component for a single joint robot. The gravitational acceleration is 9.8m/s^2): (**0.5 Marks**) (Unit: N)

dP/dq = 254.8000

Your last answer was interpreted as follows: 26

Your last answer was interpreted as follows: -152.8683

Your last answer was interpreted as follows: 254.8000

Correct answer, well done.
Correct!

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

A correct answer is 9.5, which can be typed in as follows:

```
9.5
```

A correct answer is 0.1773, which can be typed in as follows:

```
0.1773
```

A correct answer is 26.0, which can be typed in as follows:

```
26.0
```

A correct answer is -152.8683, which can be typed in as follows:

```
-152.8683
```

A correct answer is 254.8, which can be typed in as follows:

```
254.8
```

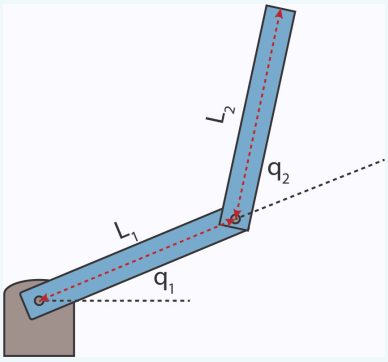
Question 3

Correct

Mark 3.00 out of 3.00

[3 Marks] Please answer with 4 decimal places for all questions

Figure below shows a two-revolute joint manipulator.



(I) Joint 1 moves with a cubic trajectory from 4 (degree) at Ts =0 (s) to 58 (degree) at $T_f = 20$ (s). The joint starts and ends at zero velocity.

Cubic trajectory: $q_1(t) = a_0 + a_1t + a_2t^2 + a_3t^3$ (degree)

Calculate the four coefficient of q_1 (**1.25 Mark**)

a_0= 4

a_1= 0

a_2= 0.4050

a_3= -0.0135

Calculate the maximum acceleration of joint 1 (**0.75 Mark**):

0.8100 (degree/s^2)

(II) This robot uses a coordinated path generation, and the trajectory of q2 is also a cubic polynomial. Assume that the maximum acceleration of joint 2 is 30% of the maximum acceleration of joint1, and q_2 starts at $q_2(0) = 10$ (degree).

Calculate the end position of joint 2: (**1 Mark**)

q_2 (T_f)= 26.2 (degree)

Your last answer was interpreted as follows: 0.4050

Your last answer was interpreted as follows: -0.0135

Your last answer was interpreted as follows: 0.8100

Your last answer was interpreted as follows: 26.2

Correct answer, well done.
Correct!

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

A correct answer is 4.0, which can be typed in as follows:

```
4.0
```

A correct answer is 0.0, which can be typed in as follows:

```
0.0
```

A correct answer is 0.405, which can be typed in as follows:

```
0.405
```

A correct answer is -0.0135, which can be typed in as follows:

```
-0.0135
```

A correct answer is 0.81, which can be typed in as follows:

```
0.81
```

A correct answer is 26.2, which can be typed in as follows:

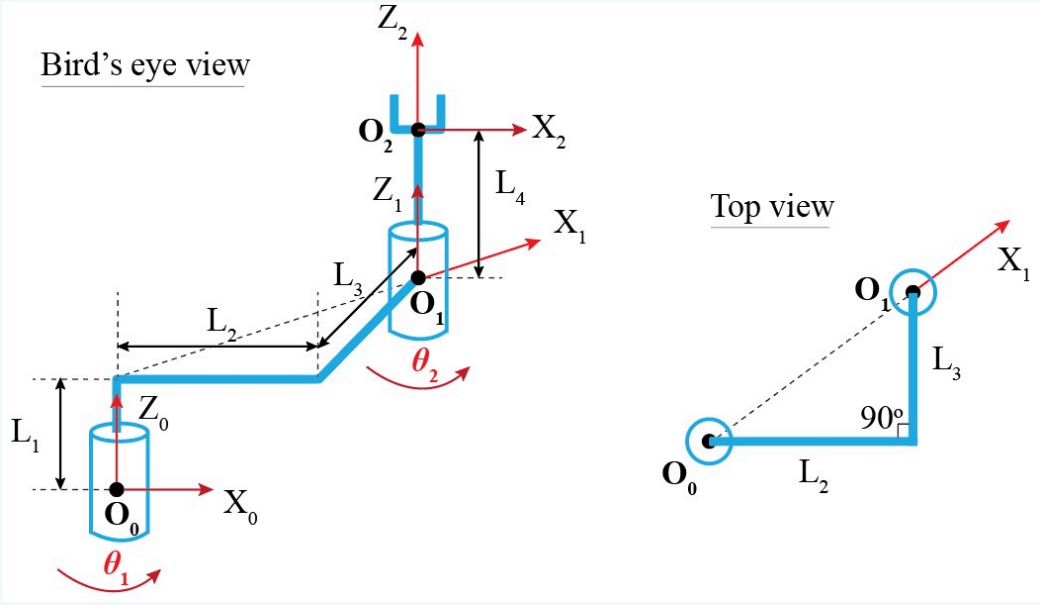
```
26.2
```

Question 4

Correct

Mark 4.00 out of 4.00

[4 Marks] Please write 4 decimal places for all answers.



A two-link robot with dimension of L_1=$0.5(m)$; L_2 =$0.5(m)$; L_3 = $0.6(m)$; and L_4 = $0.5(m)$.

The joint angles are θ_1 = 80 (degree), and θ_2 = 50 (degree).

(i) Find the DH table of this robot **[1 Marks] [HINT: REFER TO QUIZ1 REVISION IN LECTURE 5]**

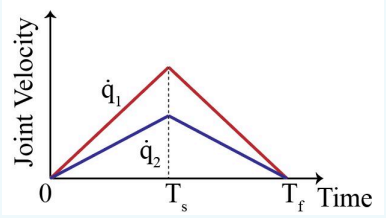
i	Theta (deg)	d (m)	a (m)	Alpha (deg)
1	130.1944	0.5	0.7810	0
2	-0.1944	0.5	0	0

(II) Calculate the velocity Jacobian **[2 Marks]**

[J_{v1} J_{v2}] =

-0.5966	0
-0.5040	0
0	0

(III) **[1 Marks]**



The two joint use a bang-bang trajectory with the same travelling time and switching time.

Joint 1 moves from 0 degree to 160 with maximum angular acceleration of $a1_{max}$ =0.25 rad/s^2 . Joint 2 moves from 0 degree to 100.

Calculate the translational velocity of the end effector at the switch time (T_s) of the bang bang trajectory. **[1 Mark]**

V = Sqrt(V_x^2+ V_y^2+ V_z^2)

V = 0.6526 (m/s)

Your last answer was interpreted as follows: 0.7810

Your last answer was interpreted as follows: 0

Your last answer was interpreted as follows: -0.1944

Your last answer was interpreted as follows: 0.5

Your last answer was interpreted as follows: 0

Your last answer was interpreted as follows: 0

Your last answer was interpreted as follows: -0.5966

Your last answer was interpreted as follows: -0.5040

Your last answer was interpreted as follows: 0

Your last answer was interpreted as follows: 0

Your last answer was interpreted as follows: 0

Your last answer was interpreted as follows: 0

Your last answer was interpreted as follows: 0.6526

Correct answer, well done.
Correct!

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

A correct answer is 130.1944, which can be typed in as follows:

```
130.1944
```

A correct answer is 0.5, which can be typed in as follows:

```
0.5
```

A correct answer is 0.781, which can be typed in as follows:

```
0.781
```

A correct answer is 0.0, which can be typed in as follows:

```
0.0
```

A correct answer is -0.1944, which can be typed in as follows:

```
-0.1944
```

A correct answer is 0.5, which can be typed in as follows:

```
0.5
```

A correct answer is 0.0, which can be typed in as follows:

```
0.0
```

A correct answer is 0.0, which can be typed in as follows:

```
0.0
```

A correct answer is -0.5966, which can be typed in as follows:

```
-0.5966
```

A correct answer is 0.0, which can be typed in as follows:

```
0.0
```

A correct answer is -0.5041, which can be typed in as follows:

```
-0.5041
```

A correct answer is 0.0, which can be typed in as follows:

```
0.0
```

A correct answer is 0.0, which can be typed in as follows:

```
0.0
```

A correct answer is 0.0, which can be typed in as follows:

```
0.0
```

A correct answer is 0.6526, which can be typed in as follows:

```
0.6526
```

Question 5

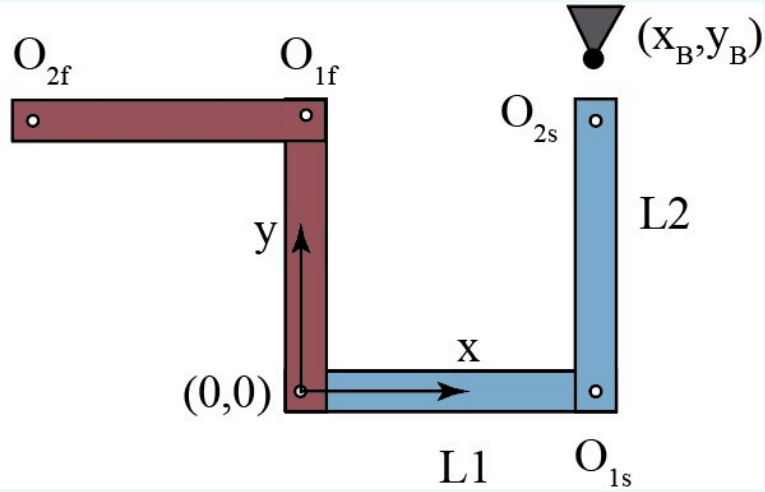
Partially correct

Mark 1.75 out of 3.50

[3.5 Marks] Please answer with 4 decimal places for all questions

The figure below shows a 2-link robot working in an environment with one triangle-shaped obstacle.

Starting position: [theta1,theta2]$_s$ =[0,90] (degree); Finish (or Goal) position: [theta1, theta2]$_f$ = [90,90] (degree)



The following artificial potential field is applied to control the robot to move to the targeted pose.

Attractive forces:

$$F_{\text{att},i}(q) = -\zeta_i \frac{(o_i(q) - o_i(q_f))}{||o_i(q) - o_i(q_f)||}$$

Repulsive forces at O_{2s} (There is no repulsive force at O_{1s})

$$F_{\text{rep}}(q) = \eta \left(\frac{1}{\rho(q)} - \frac{1}{\rho_0} \right) \frac{1}{\rho^2(q)} \nabla\rho(q)$$

The scale factors are $\zeta_1 = 7; \zeta_2 = 3;\ \eta = 4$

The thresholds $\rho_0 = 1$.

The length the two links: $L_1 = 8$ (m) and $L_2 = 2(m)$.

The coordinates of the obstacles B is $(8\ ,\ 2.6)$ in meter unit.

(I) Calculate the attractive forces at O_1: (1Marks)

F_att1_x -4.9497

F_att1_y 4.9497

Calculate the attractive forces at O_2: (1 Mark)

F_att2_x -2.1213

F_att2_y 2.1213

(II) Calculate the repulsive forces at O_2: (1.5 Marks)

F_rep2_x 0

F_rep2_y 0

Correct answer, well done.
Correct!

Correct answer, well done.

Incorrect answer.

Incorrect answer.

Correct answer, well done.

Incorrect answer.

A correct answer is -4.9497, which can be typed in as follows:

```
-4.9497
```

A correct answer is 4.9497, which can be typed in as follows:

```
4.9497
```

A correct answer is -2.5725, which can be typed in as follows:

```
-2.5725
```

A correct answer is 1.5435, which can be typed in as follows:

```
1.5435
```

A correct answer is 0.0, which can be typed in as follows:

```
0.0
```

A correct answer is -7.4074, which can be typed in as follows:

```
-7.4074
```

Question 6

Correct

Mark 3.50 out of 3.50

[3.5 Marks] Please answer with 4 decimal places for all questions

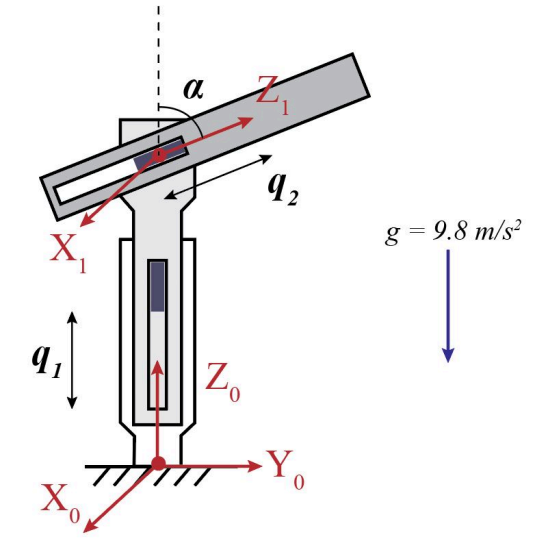


Figure above shows a robot with two prismatic joints. The distances from the centre of mass of each link to their frame origin are q1=0.4(m), and q2=0.7(m), respectively.

The weights of each link are m1 = 8(kg) and m2= 10(kg). $\alpha = 75$(degree).

[I] Calculate the translational velocity Jacobian of the centre of mass of link 1 (Jv_{c1}) and link 2 (J_{vc2}) (**0.5 Marks** for Jvc1 and **1 Mark** for Jvc2):

J_{vc1}=

0	0
0	0
1	0

J_{vc2}=

0	0
0	0.9659
1	0.2588

(II) Calculate the inertia matrix D using the Euler-Lagrange Equation

D_{11} = 18 (**0.667 Mark**)

$D_{12}=D_{21}$ = 2.5882 (**0.667 Mark**)

D_{22}= 10 (**0.667 Mark**)

Your last answer was interpreted as follows: 1

Your last answer was interpreted as follows: 0

Your last answer was interpreted as follows: 0.9659

Your last answer was interpreted as follows: 0.2588

Your last answer was interpreted as follows: 18

Your last answer was interpreted as follows: 2.5882

Your last answer was interpreted as follows: 10

Correct answer, well done.
Correct!

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

Correct answer, well done.

A correct answer is 0.0, which can be typed in as follows:

```
0.0
```

A correct answer is 0.0, which can be typed in as follows:

```
0.0
```

A correct answer is 1.0, which can be typed in as follows:

```
1.0
```

A correct answer is 0.0, which can be typed in as follows:

```
0.0
```

A correct answer is 0.9659, which can be typed in as follows:

```
0.9659
```

A correct answer is 0.2588, which can be typed in as follows:

```
0.2588
```

A correct answer is 18.0, which can be typed in as follows:

```
18.0
```

A correct answer is 2.5882, which can be typed in as follows:

```
2.5882
```

A correct answer is 10.0, which can be typed in as follows:

```
10.0
```

Previous Activity

Jump to...