Wheeled Mobile Robots

Assignment 3

1. For a given input vector, τ, calculating the resulting motion of the robot, that is, $\eta, \dot{\eta}, \ddot{\eta}$ is known as __________

   ◯ Forward kinematics
   ◯ Forward differential kinematics
   ◯ Forward dynamics
   ◯ Inverse kinematics
   ◯ Inverse differential kinematics
   ◯ Inverse dynamics

   Correct answer is **Forward dynamics**

2. For a given desired trajectory, $\eta, \dot{\eta}, \ddot{\eta}$, find the required input vector, τ is known as __________

   ◯ Forward kinematics
   ◯ Forward differential kinematics
   ◯ Forward dynamics
   ◯ Inverse kinematics
   ◯ Inverse differential kinematics
   ◯ Inverse dynamics

   Correct answer is **Inverse dynamics**

3. Lagrangian (L) is equal to __________

   ◯ Kinetic energy + Potential energy
   ◯ Kinetic energy - Potential energy
   ◯ Kinetic energy × Potential energy
   ◯ Kinetic energy / Potential energy
   ◯ Potential energy- Kinetic energy
   ◯ Potential energy / Kinetic energy

   Correct answer is **Kinetic energy - Potential energy**

4. If the equation of motion of a mobile robot is written in the following form $\mathbf{D}\dot{\boldsymbol{\zeta}} + \mathbf{n}\left(\boldsymbol{\zeta}\right) = \boldsymbol{\tau}$, then the nature of matric $\mathbf{D}$ will be __________

   ◯ $\mathbf{D}^T = \mathbf{D} < 0$
   ◯ $\mathbf{D}^T = \mathbf{D} > 0$
   ◯ $\mathbf{D}^T \neq \mathbf{D}, \mathbf{D} < 0$
   ◯ $\mathbf{D}^T \neq \mathbf{D}, \mathbf{D} > 0$
   ◯ $\mathbf{D}^{-1} = \mathbf{D}, \mathbf{D} < 0$
   ◯ $\mathbf{D}^{-1} = \mathbf{D}, \mathbf{D} > 0$

   Correct answer is $\mathbf{D}^T = \mathbf{D} > 0$

5. Assuming that,
   $\boldsymbol{\tau}_\eta$ is the vector of applied forces and moments w.r.t to inertial frame,
   $\boldsymbol{\tau}$ is the vector of applied forces and moments w.r.t to body frame. Further, $\mathbf{J}\left(\boldsymbol{\eta}\right)$ is the Jacobian matrix which maps derivatives of generalized coordinates to the input velocity commands. Then the relation between $\boldsymbol{\tau}_\eta and \boldsymbol{\tau}$ can be written as __________

   ◯ $\boldsymbol{\tau} = \mathbf{J}\left(\boldsymbol{\eta}\right)\boldsymbol{\tau}_\eta$

- ◯ $\boldsymbol{\tau} + \boldsymbol{\tau}_{\eta} = 0$
- ◯ $\boldsymbol{\tau} = \mathbf{J}^{T}(\boldsymbol{\eta})\,\boldsymbol{\tau}_{\eta}$
- ◯ $\boldsymbol{\tau} - \boldsymbol{\tau}_{\eta} = \mathbf{J}^{T}(\boldsymbol{\eta})$
- ◯ $\boldsymbol{\tau} + \boldsymbol{\tau}_{\eta} = \mathbf{J}^{T}(\boldsymbol{\eta})$
- ◯ $\boldsymbol{\tau} - \boldsymbol{\tau}_{\eta} = 0$

Correct answer is $\boldsymbol{\tau} = \mathbf{J}^{T}(\boldsymbol{\eta})\,\boldsymbol{\tau}_{\eta}$

6. In a given differential wheel drive mobile robot, if the first (left) wheel generating a traction force of 1 N and the second (right) wheel also generating a traction force of 2 N. Then, what will be the forward and lateral direction forces?

- ◯ 2 N, 1 N
- ◯ 3 N, 1 N
- ◯ 3 N, 0 N
- ◯ 1 N, 2 N
- ◯ 1 N, 3 N
- ◯ 0 N, 3 N

Correct answer is **3 N, 0 N**

7. In a given differential wheel drive mobile robot, if the first (left) wheel generating a traction force of 1 N and the second (right) wheel also generating a traction force of 2 N. Then, what will be the vehicle motion?

- ◯ move forward
- ◯ move backward
- ◯ move forward and rotate counter-clock wise direction
- ◯ move forward and rotate clock wise direction
- ◯ move upward (left direction)
- ◯ move downward (right direction)

Correct answer is **move forward and rotate counter-clock wise direction**

8. For a given mecanum wheel drive, the wheel configuration matrix in dynamic level can be written as follows:
$\begin{bmatrix} F_x \\ F_y \\ M_z \end{bmatrix} = \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 \\ l-d & l-d & -(l-d) & -(l-d) \end{bmatrix} \begin{bmatrix} F_1 \\ F_2 \\ F_3 \\ F_4 \end{bmatrix}$, if the vehicle needs to move in the lateral direction towards right, then what would be the individual wheel forces?

- ◯ $F_1 = F, F_2 = F, F_3 = F, F_4 = F$
- ◯ $F_1 = F, F_2 = F, F_3 = -F, F_4 = -F$
- ◯ $F_1 = -F, F_2 = F, F_3 = -F, F_4 = F$
- ◯ $F_1 = F, F_2 = -F, F_3 = F, F_4 = -F$
- ◯ $F_1 = -F, F_2 = -F, F_3 = F, F_4 = F$
- ◯ $F_1 = -F, F_2 = -F, F_3 = -F, F_4 = -F$

Correct answer is $F_1 = -F, F_2 = F, F_3 = -F, F_4 = F$**.**

9. For a given mecanum wheel drive, the wheel configuration matrix in dynamic level can be written as follows:
$\begin{bmatrix} F_x \\ F_y \\ M_z \end{bmatrix} = \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 \\ l-d & l-d & -(l-d) & -(l-d) \end{bmatrix} \begin{bmatrix} F_1 \\ F_2 \\ F_3 \\ F_4 \end{bmatrix}$, if the vehicle needs to move in the lateral direction towards left, then what would be the individual wheel forces?

- ◯ $F_1 = F, F_2 = F, F_3 = F, F_4 = F$

○ $F_1 = F, F_2 = F, F_3 = -F, F_4 = -F$

○ $F_1 = -F, F_2 = F, F_3 = -F, F_4 = F$

○ $F_1 = F, F_2 = -F, F_3 = F, F_4 = -F$

○ $F_1 = -F, F_2 = -F, F_3 = F, F_4 = F$

○ $F_1 = -F, F_2 = -F, F_3 = -F, F_4 = -F$

Correct answer is $F_1 = F, F_2 = -F, F_3 = F, F_4 = -F$.

10. For a given mecanum wheel drive, the wheel configuration matrix in dynamic level can be written as follows:
$\begin{bmatrix} F_x \\ F_y \\ M_z \end{bmatrix} = \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 \\ l-d & l-d & -(l-d) & -(l-d) \end{bmatrix} \begin{bmatrix} F_1 \\ F_2 \\ F_3 \\ F_4 \end{bmatrix}$, if the vehicle needs to rotate in the clockwise direction its own position, then what would be the individual wheel forces?

○ $F_1 = F, F_2 = F, F_3 = F, F_4 = F$

○ $F_1 = F, F_2 = F, F_3 = -F, F_4 = -F$

○ $F_1 = -F, F_2 = F, F_3 = -F, F_4 = F$

○ $F_1 = F, F_2 = -F, F_3 = F, F_4 = -F$

○ $F_1 = -F, F_2 = -F, F_3 = F, F_4 = F$

○ $F_1 = -F, F_2 = -F, F_3 = -F, F_4 = -F$

Correct answer is $F_1 = -F, F_2 = -F, F_3 = F, F_4 = F$.

11. If the given matrix $\mathbf{A} = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 \\ 0.2 & 0.2 & -0.2 & 0.2 \end{bmatrix}$, what will be the Moore Penrose pseudo inverse matrix of $\mathbf{A}$?

○ $\mathbf{A}^+ = \begin{bmatrix} 0.25 & 0.25 & 1.25 \\ 0.25 & -0.25 & 1.25 \\ 0.25 & 0.25 & -1.25 \\ 0.25 & -0.25 & -1.25 \end{bmatrix}$

○ $\mathbf{A}^+ = \begin{bmatrix} 0.25 & 0.25 & 1.25 \\ 0.25 & 0.25 & 1.25 \\ 0.25 & 0.25 & -1.25 \\ 0.25 & 0.25 & -1.25 \end{bmatrix}$

○ $\mathbf{A}^+ = \begin{bmatrix} 0.25 & -0.25 & 1.25 \\ 0.25 & 0.25 & 1.25 \\ 0.25 & -0.25 & -1.25 \\ 0.25 & 0.25 & -1.25 \end{bmatrix}$

○ $\mathbf{A}^+ = \begin{bmatrix} 1 & 1 & 0.2 \\ 1 & -1 & 0.2 \\ 1 & 1 & -0.2 \\ 1 & -1 & -0.2 \end{bmatrix}$

○ $\mathbf{A}^+ = \begin{bmatrix} 1 & 1 & 0.2 \\ 1 & 1 & 0.2 \\ 1 & 1 & -0.2 \\ 1 & 1 & -0.2 \end{bmatrix}$

○ $\mathbf{A}^+ = \begin{bmatrix} 1 & -1 & 0.2 \\ 1 & 1 & 0.2 \\ 1 & -1 & -0.2 \\ 1 & 1 & -0.2 \end{bmatrix}$

Correct answer is $\mathbf{A}^+ = \begin{bmatrix} 0.25 & 0.25 & 1.25 \\ 0.25 & -0.25 & 1.25 \\ 0.25 & 0.25 & -1.25 \\ 0.25 & -0.25 & -1.25 \end{bmatrix}$

12. The inertia matrix of a mobile robot with respect to body frame is given as:
$\mathbf{D} = \begin{bmatrix} 10 & 0 & 0.5 \\ 0 & 10 & 0.1 \\ 0.5 & 0.1 & 1 \end{bmatrix}$,
if the vehicle orientation is 60 deg with respect to inertia frame (x axis), what will be the inertia matrix with respect to inertial frame?

- ○ $\mathbf{D}_\eta = \begin{bmatrix} 10 & 0 & 0.5 \\ 0 & 10 & 0.1 \\ 0.5 & 0.1 & 1 \end{bmatrix}$
- ○ $\mathbf{D}_\eta = \begin{bmatrix} 10 & 0 & 0.1634 \\ 0 & 10 & 0.483 \\ 0.1634 & 0.483 & 1 \end{bmatrix}$
- ○ $\mathbf{D}_\eta = \begin{bmatrix} 10 & 0 & -0.1634 \\ 0 & 10 & -0.483 \\ 0.1634 & 0.483 & 1 \end{bmatrix}$
- ○ $\mathbf{D}_\eta = \begin{bmatrix} 10 & 0 & -0.1634 \\ 0 & 10 & -0.483 \\ -0.1634 & -0.483 & 1 \end{bmatrix}$
- ○ $\mathbf{D}_\eta = \begin{bmatrix} 0 & 0 & -0.1634 \\ 0 & 0 & -0.483 \\ 0.1634 & 0.483 & 0 \end{bmatrix}$
- ○ $\mathbf{D}_\eta = \begin{bmatrix} 10 & 0 & -0.1634 \\ 0 & 10 & 0.483 \\ 0.1634 & -0.483 & 1 \end{bmatrix}$

Correct answer is $\mathbf{D}_\eta = \begin{bmatrix} 10 & 0 & 0.1634 \\ 0 & 10 & 0.483 \\ 0.1634 & 0.483 & 1 \end{bmatrix}$