Name: **Enrolment No:**	UPES UNIVERSITY OF TOMORROW

UPES

End Semester Examination, May 2025

Course:	**Industrial and Service Robots**	**Semester:**	**II**
Program:	**M. Tech (Robotics)**	**Time:**	**03 hrs**
Course Code:	ECEG7030	**Max. Marks:**	**100**

Instructions:
1. Carefully read all the questions before attempting.
2. Assume any missing data and clearly state your assumptions.
3. Provide detailed explanations and show all necessary calculations.
4. Use appropriate units and notation where required.
5. Diagrams and sketches should be neat and labelled properly.

SECTION A

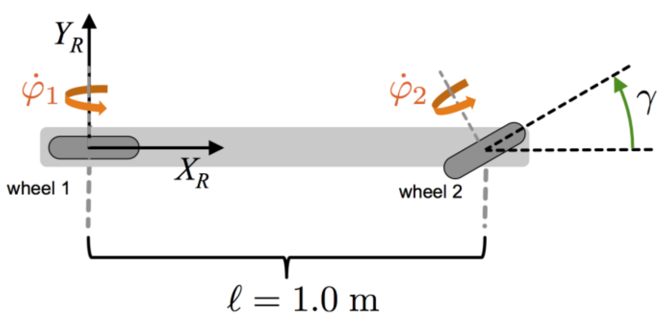
(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	Define the term "odometry".	**4**	**CO1**
Q 2	Describe how differential drive kinematics affect robot movement.	**4**	**CO1**
Q 3	Name three sources of uncertainty in localisation.	**4**	**CO2**
Q 4	Name a few domestic robots that are used for cleaning and housekeeping purposes.	**4**	**CO2**
Q 5	Define exteroceptive and proprioceptive sensors with examples.	**4**	**CO1**

SECTION B

(4Qx10M= 40 Marks)

Q 6	A differential drive robot has two wheels spaced 0.5 meters apart. Calculate the robot's linear and angular velocity if the left wheel rotates at a velocity of 1.0 m/s and the right wheel rotates at 0.5 m/s. **Hint:** *Think about how the difference in wheel speeds and the distance between the wheels influence the robot's turning rate.*	**10**	**CO3**
Q 7	Compare the rolling and sliding constraints of a steered standard wheel and a castor wheel. Discuss the advantages and disadvantages of each wheel type in terms of maneuverability and control. OR A mobile robot uses sensor and motion data for localization in a structured indoor environment. Apply your understanding of Kalman and Extended Kalman Filters to explain how each filter would process	**10**	**CO2**

	uncertain motion and noisy sensor measurements. Provide a scenario or example to support your explanation.		
Q 8	A robot is using a range sensor to determine its position in a known environment. The robot has two possible locations: H_1 (near a wall) and H_2 (away from a wall). The range sensor provides a reading ***E*** indicating a short distance to an obstacle. Given: • Prior probabilities: $P(H_1) = 0.6$, $P(H_2) = 0.4$. • Sensor model: $P(E\|H_1) = 0.9$, $P(E\|H_2) = 0.2$. Compute the probability that the robot is near the wall given the sensor reading.	**10**	**CO3**
Q 9	Consider the bicycle robot shown in the figure below. This robot has two standard wheels arranged so that positive wheel rotation makes the bicycle drive forward, along with the robot's x-direction.  • The rear wheel is fixed to the robot, but the front wheel is steerable. The steering angle is denoted by γ. • The distance between the wheel centres, l, is 1 meter, and each wheel has a radius of 0.3 meters. • Answer the following questions: a) How many degrees of steerability and mobility does this robot have? b) Derive the kinematic equations of motion for this robot.	**10**	**CO4**
SECTION-C (2Qx20M=40 Marks)			
Q 10	A robot is placed in a 3×3 grid world, where each cell is labelled by coordinates (x, y), with x and y ranging from 0 to 2. Some cells contain landmarks (L), while others do not (NL = No Landmark). The robot does not know its starting position. It uses sensor readings and movement to estimate where it is, updating its belief using Bayesian methods.	**20**	**CO4**

(0,2): L	(1,2): NL	(2,2): NL
(0,1): NL	(1,1): L	(2,1): NL
(0,0): NL	(1,0): NL	(2,0): L

Sensor Model:

- *P(sense landmark | landmark)* = 0.9
- *P(sense landmark | no landmark)* = 0.1

Motion Model:

- 80% chance the robot moves correctly as per command
- 10% chance the robot stays in the same cell
- There is a 10% chance it overshoots and moves two cells in the forward direction.
- If a move took it outside the grid, it is considered impossible (probability =0).

Based on this, predict the robot's belief about its position after it moves one cell to the right, followed by one cell upward (increasing y).

Q 11

A robot is moving along a **one-dimensional path (1D)** and is using a **Kalman filter** to estimate its position. The only state variable is the robot's position x.

At time step t = 0:

- Initial estimated position: $\hat{x}_0 = 2$
- Initial uncertainty (variance): P_0 = 1.5

At each time step, the robot:

- Moves forward by 2 meter, with process noise variance Q = 0.3
- Receives a noisy measurement of its position with measurement noise variance R = 0.4

At time step t = 1, the robot receives a sensor measurement: z_1 = 4.1

Using the Kalman filter, perform the following steps:

1. Predict the robot's position after the move.
2. Update the estimate using the sensor measurement.

OR

A differential drive robot has its left and right wheel angular velocities set to 6 rad/sec and 10 rad/sec, respectively. Calculate the robot's pose after 3 seconds. The distance between the two wheels (track width) is 0.8 meters, and each wheel has a radius of 0.3 meters. The reference point of the robot coordinate system is located at the midpoint of the line connecting the contact points of the wheels with the ground.

20

CO4