K. K. Wagh Institute of Engineering Education & Research, Nashik

(An Autonomous Institute From A.Y. 2022-23)

WINTER-2025	
Exam Seat No.:	
Academic Year:2025-2026	Semester:VI
Class:TY	Program:B.Tech
Branch Code:ROB	Pattern:2022
Name of Course:Swarm Robotics	Course Code:ROB223017
Max. Marks:60	Duration:2.30 Hrs.

Instructions: Candidates should read carefully the instructions printed on the Question Paper and on the cover page of the Answer Book, which is provided for their use.

1. This question paper contains 05 page(s).
2. Answer to each new question is to be started on a new page.
3. Assume suitable data wherever required, but justify it.
4. Draw the neat labelled diagrams, wherever necessary.
5. The last columns indicates the Course Outcome and level of Blooms Taxonomy of the Question/sub-question.

		Marks	CO
Question No. 1			
1a)	Explain the following terms of Swarm robotics a) Robustness b) Scalability	(6)	CO1
Question No. 2			
2a)	PSO algorithm is used to minimize a function $xy - x^2$. The initial positions of five birds in the swarm are (1,3), (4,7), (3,2), (6,1), (5,5). Calculate the updated velocity and position of a bird at position (6,1). Also calculate the function value at this new position. Given that : Current velocity of a particle : (4,4) Inertia coefficient: 0.6 Cognitive factor: 1.6 Social factor: 1.8 Random number (r1)= 0.45 Random number (r2)= 0.72	(6)	CO2, CO3
Question No. 3			
3a)	Explain market based task allocation in swarm robotics with a suitable example.	(8)	CO2, CO3
	OR		
3b)	Explain threshold based task allocation in swarm robotics with a suitable example.	(8)	CO2, CO3

3c) A warehouse has 5 autonomous robots (R1 to R5) performing three types of maintenance tasks: (8) CO2, CO3

Floor Cleaning (T1) – dust density (particles/cm²),

Shelf Restocking (T2) – product shortage (items/m²) ,

Package Sorting (T3) – pending parcels (packages/hour).

Each robot has different thresholds for each task.

Robot	Floor Cleaning (T1) Threshold (particles/cm²)	Shelf Restocking (T2) Threshold (items/m²)	Package Sorting (T3) Threshold (packages/hour)
R1	30	20	50
R2	39	18	41
R3	40	22	55
R4	25	30	40
R5	20	25	60

Current Task Stimulus Levels are mentioned below.

Task	Stimulus Level
T1 (Floor Cleaning)	35 particles/cm²
T2 (Shelf Restocking)	27 items/m²
T3 (Package Sorting)	45 packages/hour

a) According to Threshold-based task allocation; which robots can take task:

T1 (Floor Cleaning),T2 (Shelf Restocking) and T3 (Package Sorting).

b) After threshold-based task allocation; if multiple robots can do the same task, then assign a single robot from those multiple robots to do the task according to the Market-based task allocation.

Robot	Floor Cleaning (T1) (Time taken)	Shelf Restocking (T2) (Time taken)	Package Sorting (T3) (Time taken)
R1	10	20	8
R2	20	15	10
R3	18	18	16
R4	25	15	6
R5	14	12	14

c) Assign the remaining 2 robots to 2 tasks. At the end; write the final allotment of robots to different tasks.

OR

3d) A swarm of 5 robots (R1, R2, R3, R4, R5) needs to perform 2 types of tasks: (8) CO2, CO3

Task X (Surveillance)

Task Y (Resource Transport)

The response thresholds for each robot are as follows:

Robot	Threshold for Task X	Threshold for Task Y
R1	20	50
R2	30	40
R3	25	35
R4	45	30
R5	50	25

Current task stimulus levels are mentioned below:

Task	Stimulus Level
Task X	32
Task Y	34

a) According to Threshold-based task allocation; which robots can take task X and task Y.

b) After threshold-based task allocation; if multiple robots can do the same task, then assign a single robot from those multiple robots to do the task according to the Market-based task allocation.

Robot	Cost for Task X	Cost for Task Y
R1	45	15
R2	15	25
R3	12	35
R4	40	20
R5	10	30

c) Assign one more single robot to each task from the remaining 3 robots by using Market based task allocation and Threshold based task allocation. At the end; write the final allotment of robots to different tasks.

d) For the remaining single robot; what should be the threshold value so that it can take both tasks X and Y.

Question No. 4

4a) Describe frontier-based exploration for swarm robotics. (8) CO3, CO4

OR

4b) Compare potential field-based navigation with bio-inspired path planning techniques used in swarm robotics. (8) CO3, CO4

4c) A boid is located at position P_A= (5,8) and has a velocity V_A= (1,2). Three neighbouring boids have the following positions and velocities: (8) CO3, CO4

Boid	Position (P_i)	Velocity (V_i)
B1	(7,6)	(1,1)
B2	(4,4)	(0,1)
B3	(6,3)	(1,-1)

Assume the influence of cohesion, alignment and separation as 40%, 40% and 20% respectively. Compute the new velocity V_{new} for Boid A.

OR

4d) A mobile robot is navigating a 4×4 grid (0-indexed). The goal is located at cell (3,3), while an obstacle blocks cell (1,2). The robot starts from position (2,1). The robot can move in North, South, East and West directions. Use Potential Field-Based Navigation with the following parameters: (8) CO3, CO4

Attractive potential:

$$U_{att} = 0.5 \cdot k_{att} \cdot d_{goal}^2$$

Repulsive potential:

$$U_{rep} = \begin{cases} 0.5 \cdot k_{rep} \cdot \left(\frac{1}{d_{obs}} - \frac{1}{d_0}\right)^2, & \text{if } d_{obs} < d_0 \\ 0, & \text{otherwise} \end{cases}$$

Constants:

$$k_{att} = 1, k_{rep} = 100, d_0 = 2$$

Determine the next cells the robot should move according to the potential field based navigation.

Question No. 5

5a) Describe the concept of Human swarm interaction. (8) CO3, CO4

OR

5b) Write a short note on ethical considerations and societal impacts associated with the deployment of swarm robotics. (8) CO3, CO4

5c) Discuss the application of Swarm Robotics in Search and Rescue (SAR) missions. Explain the advantages, limitations, and key algorithms used for exploration and victim detection. (8) CO3, CO4

OR

5d) Distinguish between Multi-Robot Systems (MRS) and Swarm Robotics. (8) CO3, CO4

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