

Exam #1 Notes

Braitenberg Vehicles: Given a vehicle in an environment, describe the vehicle's motion and denote its trajectory by drawing an arrow

Intro (historical perspective and hierarchical paradigm): Explain the outside influences on the field of robotics.

Motor and gears: Draw a graph of the relationship between motor torque and motor velocity, voltage, current, and gear ratio. The sample problem we discussed in class (given motor spec's what is the max weight?)

Locomotion: Discuss the advantages and disadvantages of the different wheel configurations

Kinematics: given the parameters and starting location, compute the new position (Differential drive, tricycle drive, PalmPilot Robot) **OR** degree of mobility and degree of steerability for different robot types **OR** holonomic vs. non-holonomic

Biological Foundations: Discuss the influence of observed animal behaviors on control strategies for mobile robots. Explain the terms reflexes, taxes, fixed action patterns, schema, affordance, innate releasing mechanism

Other terms: behavior, imprinting, closed world assumption, frame problem

Reactive Paradigm: given an obstacle avoidance strategy and environment, compute the robot trajectory and draw a diagram **OR** given an application problem, design a subsumption and/or potential fields robot

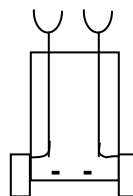
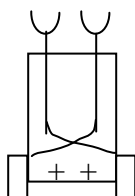
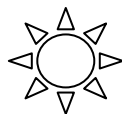
Architectures: Given a diagram of a robot architecture, decide which paradigm it follows and explain why **OR** given an application problem, decided which paradigm would work best and justify your answer

Sensing: Describe common sensing components for mobile robots, how they work, limitations, strengths **OR** design a sensing system for a specified application

Sensor Characterization: Given a graph and/or description of sensor readings, compute the sensitivity, dynamic range, error, accuracy, precision, resolution.

EXAMPLE QUESTIONS

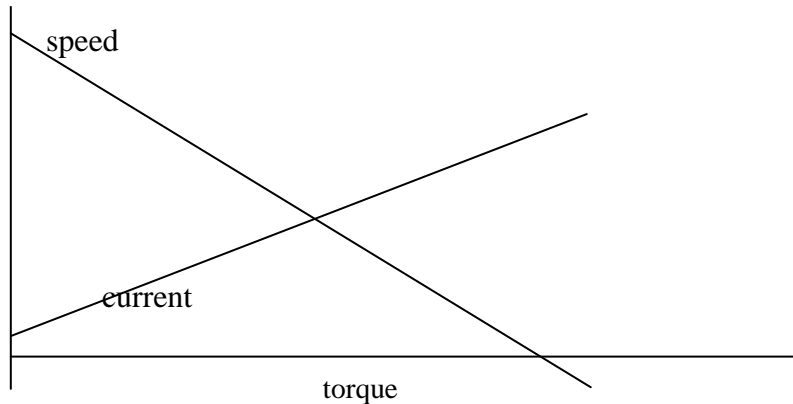
1. The diagram below shows versions of Vehicle 2 and Vehicle 3, as proposed by Braitenberg. The + **sign indicates a positive response** to a stimulus (light). The – **sign indicates a negative response** to a stimulus. Explain the behavior of each vehicle in the presence of light. Include a short explanation and show the behavior on the diagram.



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2. Label the following points on the graph below:

- (a) **No-load speed, N_0**
- (b) **Stall torque, T_S**
- (c) Draw a new curve on the graph for **speed vs. torque**, assuming a **gear ratio = 2**



3. Suppose you are given a range sensor that detects the distance in whole numbers of cm. It returns values from 12 to 250, which can be interpreted as the range in cm. When the measured reading is compared to the actual distance, the reading is always within 1.0 cm of the correct value. Compute the **sensitivity** and **dynamic range** of the sensor.

4. Consider a differential drive mobile robot with a weight of 10 lbs. Each of the two drive wheels is driven by an identical motor and gear train. For each motor, the motor speed, N_M (in RPM, i.e., revolutions per minute), with the gear train, is given below as a function of the torque, τ_M (in lb-ft.):

$$N_M = -610 \tau_M + 260$$

- (a) Given the equation above, what is the **no-load speed** of the motor/gear train mechanism?
 - (b) **Determine the radius of a wheel that will result in a maximum linear velocity of the robot.** The coefficient of rolling friction between the wheels and a flat surface is $\mu_R = 0.42$. Assume the weight of the robot is balanced equally over the two wheels.
5. Given a starting Cartesian pose of (0, 0, 0), **compute the velocity in the global frame** for the robot described below. Show your calculations and include units.

Velocity of the right wheel = 50 encoder clicks / second

Velocity of the left wheel = 20 encoder clicks / second

Encoder clicks per wheel revolution = 30

Wheel radius = 4 cm

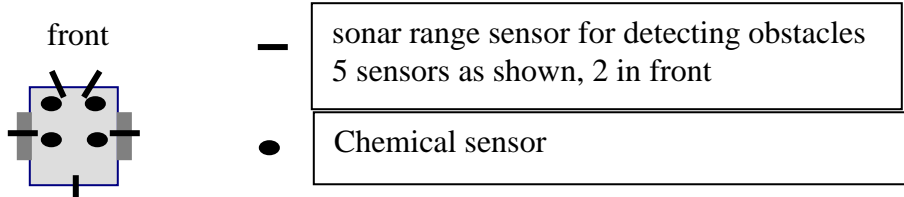
Distance between the wheels = 22 cm

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6. Using the same robot described above in problem 5, assume a starting Cartesian pose of $(0, 0, 60 \text{ degrees})$. **Compute the velocity in the global frame** if the velocities of the right wheel and left wheel are both 12 radians/sec. Then **compute a new Cartesian pose after 5 seconds**. **Draw a sketch** to show the starting and ending positions.

7. Consider the robot described below, which has been designed to clean up chemical spills. The robot has the following reactive behaviors:

- (1) move to the center of the chemical spill (detected by “smell”)
- (2) avoid obstacles (detected by sonar sensors)



Robot
(top view)

Outline an architecture that includes both of the behaviors using

- (a) **Subsumption architecture**
- (b) **Potential fields**

For each architecture, include a diagram that shows the behaviors with their inputs and outputs and shows how the behaviors are combined. Consider the two environmental conditions shown below and explain how you would implement each behavior to robustly handle these conditions and others.

