

# Introduction to Unmanned Ground Vehicles

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ECE 495/595 – Winter 2017

## Homework #5 – Take-Home Exam

**Due: Monday, February 27<sup>th</sup>**

The purpose of this assignment is to accompany the GPS simulation project and ensure that the student thoroughly understands the concepts discussed so far in the course before moving on to more advanced topics.

Complete the exam on the following pages, putting your answers in a separate document. Use whichever tools you want (Word, L<sup>A</sup>T<sub>E</sub>X, etc.). You can submit your answers via email (mtradovn@oakland.edu) or by adding the document to your repository and pushing it.

**The late penalty for this homework will be 10% per 24 hours late  
instead of the normal homework rate of 2%**

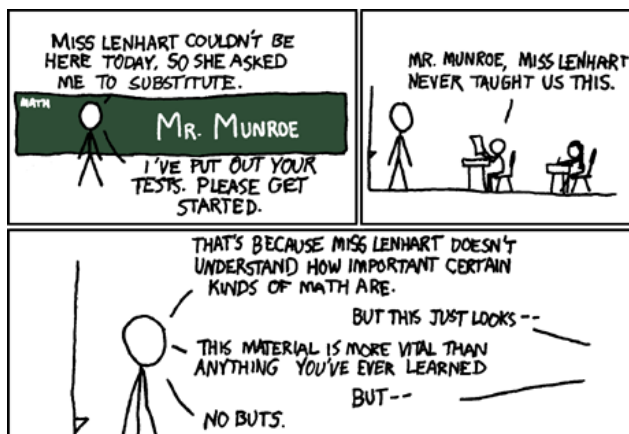
# ECE 495/595 – Intro to Unmanned Ground Vehicles

## Midterm Exam

Instructor: Micho Radovnikovich

### Score

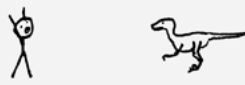
Question:	1	2	3	4	5	6	7	Total
Points:	25	10	10	20	15	10	10	100
Score:								



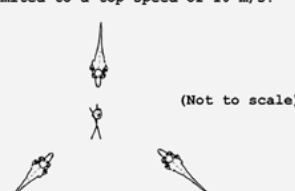
— THIS IS A MATTER OF LIFE AND DEATH.

Name: \_\_\_\_\_

1. The velociraptor spots you 40 meters away and attacks, accelerating at  $4 \text{ m/s}^2$  up to its top speed of 25 m/s. When it spots you, you begin to flee, quickly reaching your top speed of 6 m/s. How far can you get before you're caught and devoured?



2. You are at the center of a 20m equilateral triangle with a raptor at each corner. The top raptor has a wounded leg and is limited to a top speed of 10 m/s.



(Not to scale)

The raptors will run toward you. At what angle should you run to maximize the time you stay alive?

3. Raptors can open doors, but they are slowed by them. Using the floor plan on the next page, plot a route through the building, assuming raptors take 5 minutes to open the first door and halve the time for each subsequent door. Remember, raptors run at 10 m/s and they do not know fear.

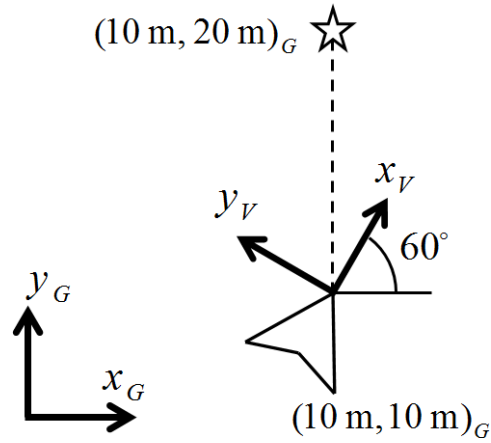
<http://xkcd.com/135/>

1. Short answer problems

- (a) [5 points] Which two files are present in every ROS package?
  
  
  
  
  
  
  
  
  
  
- (b) [5 points] Cite an example where a private node handle could be used.
  
  
  
  
  
  
  
  
  
  
- (c) [5 points] A complete representation of a coordinate frame transformation consists of what?
  
  
  
  
  
  
  
  
  
  
- (d) [5 points] What is a YAML file used for?
  
  
  
  
  
  
  
  
  
  
- (e) [5 points] The determinant of a rotation matrix must be equal to +1 in order to correctly rotate points from one frame to another. Why is this?

2. [10 points] Convert the GPS coordinates ( $30^{\circ} 30' 36.00''$  S,  $5^{\circ} 40' 40.00''$  E) into decimal degrees.
3. Consider two frames whose orientations differ by a pitch angle of 90 degrees, and a yaw angle of 135 degrees.
- (a) [5 points] Compute the rotation matrix that would be used to rotate points in one reference frame to the other.
- (b) [5 points] What would be the  $x$  component of the quaternion representation of this rotation?

4. Consider a mobile robot navigating to a GPS waypoint, as illustrated below:



The vehicle's coordinates are  $(10, 10)$  in the global reference frame  $G$ , and the waypoint's coordinates are  $(10, 20)$  in  $G$ .

- (a) [5 points] Compute the rotation matrix and translation vector from global frame  $G$  to vehicle frame  $V$ .
- (b) [10 points] Compute the coordinates of the waypoint relative to vehicle frame  $V$ .
- (c) [5 points] What is the equivalent quaternion that represents the same rotation from  $G$  to  $V$ ?

5. Consider a differential drive vehicle with wheel radius 0.1 meters, and a distance of 0.5 meters between the wheels.

(a) [10 points] If the left wheel is rotating forward at 4 rad/s, and the right wheel isn't rotating at all, compute the forward speed and yaw rate of the vehicle.

(b) [5 points] What ROS message type would you use to report this velocity? How would you populate the message?

6. [10 points] Describe and/or list the procedure for converting geodetic GPS coordinates into East-North-Up.

7. [10 points] Describe and/or list the procedure for advertising a service in a ROS node (entire process, not just the C++ code).