

Midterm 1 for Calculus-Based Physics-1: Mechanics (PHYS150-01)

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September 25th, 2017

1 Estimation, Approximation, and Unit Analysis

1. There is a jar full of candies. Estimate the number of candies in the jar, if this type of round candy has a radius of ≈ 1 cm, and the jar has a radius of ≈ 10 cm, and a similar height. (Remember, the answer only has to be accurate to the correct order of magnitude).
2. An explorer lands on Mars, which has an acceleration due to gravity of $\approx 0.1g$. If the explorer drops a bag from shoulder height, how long does it take to reach the ground?
3. Our bodies contain special nerve fibers from the spinal cord to extremities, for quick reactions. Suppose a curious child, who is 1 m tall, touches a flame. The child's body jerks the hand away after 10 milliseconds (0.01 seconds). What was the speed of the nerve signal?
 - A: 1 m
 - B: 10 m/s
 - C: 100 m/s
 - D: 10 s

2 Displacement, Velocity, and Constant Acceleration

1. In the film *The Hunt for Red October*, one scene depicts two Soviet officers at the helm of a submarine they are navigating through an undersea canyon. Their current speed is 35 kilometers per hour, and the canyon turns 45 degrees to their right 1 kilometer ahead. In how many seconds must they order the ship to turn before crashing into the side of the canyon? After the turn, they adjust the speed to 18 kilometers per hour, and travel for 100 seconds. What is the displacement vector from the original position?
2. A torpedo is dropped in the water 1 km behind the *Red October* by an overflying aircraft, and it accelerates at 3 m/s^2 , with an initial velocity of 5 m/s. If the *Red October* does not alter course, but continues at 5 m/s (18 kilometers per hour), when will the torpedo reach it?

3 Vectors and Relative Motion

1. A particle has a velocity vector $\vec{v}(t) = (4t\hat{i} + 2\hat{j})$ m/s. What is the instantaneous acceleration vector? What is the instantaneous acceleration at $t = 4$ seconds?
2. An observer is moving with a velocity $\vec{v}_O(t) = -4\hat{i}$. What is the particle velocity from the perspective of the observer at $t = 4$ seconds?
3. At $t = 4$ seconds, what is the angle between the velocity of the particle and the x-axis (\hat{i} -direction)?