ECE 5/7383 Introduction to Quantum Informatics

Homework 1

1. Choose the correct remainder of this sentence:

If no net force acts on an object then,

(A) the object is not accelerated.
(B) the object is at rest.
(C) the velocity of the object decreases.
(D) the object cannot travel at a constant velocity.

2. A point mass of 5 kg in an x-y plane undergoes an acceleration of 3 m/s^2 in the x-direction and 5 m/s^2 in the y-direction. Let **i** represent the unit vector in the positive-x direction and **j** represent the unit vector in the positive-y direction. Then the acceleration vector is $\mathbf{a}=3\mathbf{i}+5\mathbf{j}$.

   a) Determine the force (as a vector quantity) that must be present to cause this acceleration.

   b) Determine the magnitude of the force in Newtons.

3. A hockey puck is modeled as a 10 g point mass and is initially at rest on a frictionless sheet of ice. Assume that the puck is at the origin and that the sheet of ice is representative of an x-y plane. A toy rocket engine of negligible mass is lying on its side and fastened to the top of the puck such that its exhaust exerts a force in the x-y plane. At time t=0 s, the rocket engine fires and remains firing until it burns out at time t=3 s. At time t=3 s, the puck has a position of $\mathbf{r} = 3\mathbf{i}+4\mathbf{j}$ m and a velocity of $\mathbf{v} = 5\mathbf{i} +6\mathbf{j}$ m/s.

   a) What is the momentum of the puck at time t=3 s (give both the vector quantity and the overall magnitude)?

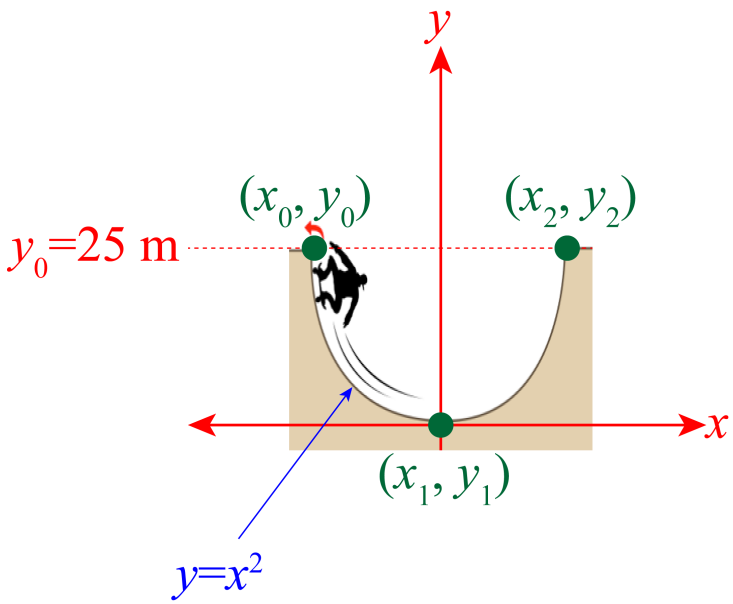
   b) How much work (in Joules, J) did the rocket engine perform on the puck from the time t=0 s to t=3 s?

   c) What is the net amount of force (magnitude only) that was exerted on the puck during the time period from t=0 s to t=3 s?

   d) At time t=0 s, what was the potential energy of the toy rocket engine?

   e) What is the average power expended by the toy rocket engine from the time period beginning t=0 s to t=3 s.

4. A 50 kg skateboarder is standing on the top of a "half-pipe" as shown in the figure and is modeled as a point mass. The cross-section of the half-pipe has a contour that is modeled as $y=x^2$ over the interval $0 \le y \le 25$ m. Assume that the skateboard has negligible mass and no friction. The skateboarder enters the half-pipe at time $t=0$s and is capable of twisting around ("kickturn" maneuver) and re-entering the half-pipe in negligible time when they reach the other side. Assume the gravitational constant is 9.8 m/s^2.



a) What is the potential energy of the skateboarder at a time that is an instant before they jump off the leftmost top of the half-pipe at $t=0$ (denoted as $t^-=0^-$)?

b) What is the instantaneous velocity of the skateboarder at the bottom of the half-pipe" (the origin of the coordinate system)?

c) What is the magnitude of the momentum, p_{0-}, of the skateboarder at time $t^-=0^-$?

d) What is the magnitude of the momentum of the skateboarder at the bottom of the half-pipe. That is, at the coordinate point $(x_1, y_1)=(0, 0)$?

e) How much work did the gravitational force perform on the skateboarder from the time that the skateboarder was at point (x_0, y_0) until the time they reached the point (x_1, y_1)?

f) (**for 7383 students only**) What is the magnitude of the acceleration on the skateboarder the instant shortly after $t=0$ s (denoted as $t^+=0^+$)?