Homework 2

SABIC: Physics

Due January 28, 2016

Reading (Due April 1, 2015):

Read Chapter 2.

Problem 1: practice with estimation

(a) How many times the acceleration due to gravity does a drag racer experience when accelerating?

Problem 2: conceptual

(a) Can an object with constant acceleration change tis direction of motion? Is there a maximum number of times this can happen?

(b) Can you have a zero displacement and a nonzero average velocity? A nonzero velocity? Illustrate your answers on an xt graph.

(c) Argue for the following statements: (i) Neglecting air resistance, anything thrown vertically upward with some speed v will return to the point at which it is thrown with that same speed; and (ii) again neglecting air resistance, the amount of time it takes to return will be twice the time it takes to get to its highest point.

(d) An object is thrown straight up into the air and feels no air resistance. Give the acceleration and velocity at its highest point.

(e) Dropping a ball from some height d without air resistance causes it to hit the ground in time T. How long does it take (in terms of T) for an object to fall that's dropped at a height $3d$?

Problem 3: Velocity

(a) A car is stopped at a traffic light. IT then travels along a straight road so that its distance from the light is given by $x(t) = bt^2 - ct^3$, where $b = 2.40\text{m/s}^2$ and $c = 1.20\text{m/s}^3$. (i) Calculate the average velocity of the car between $t = 0\text{s}$ and $t = 10.0\text{s}$. (ii) Calculate the instantaneous velocity of the care at $t = 0\text{s}$, $t = 5.0\text{s}$, and $t = 10.0\text{s}$. (iii) How long does it take for the car to return to being at rest?

(b) A lunar lander is descending toward the moon's surface. Until the lander reaches the surface, its height above the surface of the moon is given by $y(t) = b - ct + dt^2$, with $b = 800m$ the initial height of the lander, $c = 60.0$m/s, and $d = 1.05$ms^2. (i) What is the initial velocity of the lander? What is the velocity of the lander just before it reaches the lunar surface?

Problem 4: Acceleration

(a) A world-class sprinter accelerates to his maximum speed in 4.0s. He then maintains this speed for the remainder of a 100m race, finishing with a total time of 9.1s. (i) What is the runner's average acceleration during hte first 4.0s? (ii) What is his average acceleration during hte last 5.1s? (iii) What is his average acceleration for the entire race? (iv) Explain why the answer to part (iii) isn't the average of parts (i) and (ii).

(b) A 7500kg rocket blasts off vertically from the launch pad with a constant upward acceleration of 2.25m/s^2 and feels no air resistance. When it has reached a height of 525m, its engines suddenly fail so that the only force acting on it is now gravity. (i) What is the maximum height this rocket will reach above the launch pad? (ii) How much time after engine failure will elapse before the rocket crashlands on the launch pad, and how fast will it be moving just before it crashes? (iii) Sketch plots of the acceleration a, the velocity v, and position y as a function of time from the moment of blast-off ($t = 0$) until the instant it strikes the launch pad.

Problem 5: Motion under constant acceleration

(a) You throw a glob of putty straight up toward the ceiling, which is 3.60m above the point where the putty leaves your hand. The initial speed of the putty is 9.50m/s. (i) What is the speed of the putty just before it strikes the ceiling? (ii) How much time when it leaves your hand does it take the putty to reach the ceiling?

(b) A jet fighter wishes to accelerate at $5g$ (g=9.8m/s^2) to escape a dogfight as quickly as possible. Experimental evidence shows that this acceleration will black out the pilot if it lasts for longer than 5.0s. (i) What is the greatest speed the pilot can reach before blacking out? (ii) How far will the pilot travel?

(c) A basketball player jumping towards the basket seems to 'hang' in the air. Even the best athletes spend at most 1.00s in the air. Let y_{max} be the maximum height of the athlete off the ground. To see why they appear to hang in the air, calculate the ratio of the time he is above $y_{\text{max}}/2$ to the total time the athlete is off the ground. Ignore air resistance. Explain your answer.