Homework No. 02 (Spring 2024)

PHYS 205A-001: UNIVERSITY PHYSICS

School of Physics and Applied Physics, Southern Illinois University–Carbondale

Due date: Monday, 2024 Jan 29, 12:00 PM, on D2L

Instructions

- You are encouraged to use any of the resources to complete this homework. However, the extent to which you depend on resources while doing this homework is a measure of how much extra work you need to put in to master the associated concepts. Solutions should be the last resource.
- Links to solutions are provided. Further, links to few variations of the problem are provided that serve as practice problems.
- Describe your thought process in detail and organize it clearly. Make sure your answer has units and right number of significant digits.
- After completion, scan the pages as a single PDF file, and submit the file on D2L (under Assesments → Assignments). You can replace your PDF file, only the last file is graded.

Problems

1. (**10 points.**) Motion of an object moving with uniform velocity is described by the equation

$$x = vt, \tag{1}$$

where x is the position of the object, v is the velocity of the object, and t is time.

   (a) Plot x versus t for $v = 3.0\,\mathrm{m/s}$. Give a real life example that is described by this scenario.

   (b) Plot x versus t for $v = -3.0\,\mathrm{m/s}$. Give a real life example that is described by this scenario.

   (c) What is the acceleration of the object for these cases?

   [**Solution**]

2. (**10 points.**) Motion of an object moving with uniform acceleration, with intial velocity v_0, is described by the equation

$$x = v_0 t + \frac{1}{2} a t^2, \tag{2}$$

where x is the position of the object, a is the acceleration of the object, and t is time.

(a) Plot x versus t for $v_0 = 0$ and $a = 2.0\,\mathrm{m/s^2}$. Give a real life example that is described by this scenario.

(b) Plot x versus t for $v_0 = 0$ and $a = -2.0\,\mathrm{m/s^2}$. Give a real life example that is described by this scenario.

(c) Plot x versus t for $v_0 = +1.0\,\mathrm{m/s}$ and $a = 2.0\,\mathrm{m/s^2}$. Give a real life example that is described by this scenario.

(d) Plot x versus t for $v_0 = +1.0\,\mathrm{m/s}$ and $a = -2.0\,\mathrm{m/s^2}$. Give a real life example that is described by this scenario.

(e) Plot x versus t for $v_0 = -1.0\,\mathrm{m/s}$ and $a = 2.0\,\mathrm{m/s^2}$. Give a real life example that is described by this scenario.

(f) Plot x versus t for $v_0 = -1.0\,\mathrm{m/s}$ and $a = -2.0\,\mathrm{m/s^2}$. Give a real life example that is described by this scenario.

[**Solution**, 2022S MT-01 P02]

3. (**10 points.**) A particle's velocity is given by

$$v(t) = v_0 + a_0 t + \frac{1}{2} b_0 t^2. \tag{3}$$

(a) Determine the particle's acceleration as a function of time.

(b) Determine the particle's rate of change of acceleration as a function of time.

(c) Given the particle starts from rest at $t = 0$, determine the velocity of the particle when the instantaneous acceleration of the particle is zero.

[**Solution**, 2022S MT-01 P04, 2021S MT-01 P08, 2018S MT-01 P02, 2017F-001 MT-01 P02, 2017F-002 MT-01 P02, 2016F MT-01 P02, 2015F MT-01 P03, 2014F MT-01 P04]

4. (**10 points.**) The position of a particle x as a function of time t is given by

$$x(t) = 3\alpha t - \frac{\alpha}{\tau^2} t^3, \tag{4}$$

where α and τ are constants. Determine the magnitude of the acceleration of the particle when it momentarily stops.

[2021S MT-01 P08, 2017F-001 MT-01 P02, 2017F-002 MT-01 P02, 2016F MT-01 P02, 2015F MT-01 P03, 2014F MT-01 P04]

5. (**10 points.**) While standing on a 50.0 m tall building you throw a stone straight upwards at a speed of 15 m/s.

(a) How long does the stone take to reach the ground?

(b) How high above the building does the stone reach?

[**Solution**, 2023F MT-01 P05, 2023S MT-01 P05, 2022F MT-01 P03, 2022F FE P01, 2022S MT-01 P05, 2022S FE P01, 2021S FE P01, 2018S MT-01 P03, 2017F-001 MT-01 P04, 2017F-002 MT-01 P04, 2017F-002 MT-01 P05, 2016F MT-01 P05, 2014F MT-01 P02, 2014F MT-01 P03]

6. (**10 points.**) A fish is dropped by a pelican that is rising steadily at a speed 4.0 m/s. Determine the time taken for the fish to reach the water 15.0 m below. How high above the water is the pelican when the fish reaches the water?

   [**Solution**, 2021S MT-01 P07, 2018S MT-01 P04]

7. (**10 points.**) A car is traveling at 10.0 m/s, and the driver sees a traffic light turn red. After 0.500 s (the reaction time), the driver applies the brakes, and the car decelerates at 8.00 m/s^2. What is the stopping distance of the car, as measured from the point where the driver first sees the red light?

   [**Solution**, 2017F-001 MT-01 P03, 2017F-002 MT-01 P03, 2016F MT-01 P03, 2015F MT-01 P04]

8. (**10 points.**) A speeding car is moving at a constant speed of $v = 80.0$ miles/hour (35.8 m/s). A police car is initially at rest. As soon as the speeder crosses the police car the cop starts chasing the speeder at a constant acceleration of $a = 2.0\,\text{m/s}^2$. Determine the time it takes for the cop to catch up with the speeder. Determine the distance traveled by the cop in this time.

   [**Solution** 2016F MT-01 P04, 2015F MT-01 P05, 2014F FE P01]

9. (**10 points.**) A key falls from a bridge that is 50.0 m above the water. It falls directly into a boat that is moving with constant velocity, that was 10.0 m from the point of impact when the key was released. What is the speed of the boat?

   [**Solution**]

10. (**10 points.**) Imagine that a man is running at a uniform speed $v = 7.0$ m/s to catch a bus that is stopped at a traffic light. When he is still a distance $d = 10.$ m from the bus, the bus starts to move away with a constant acceleration $a = 2.0\,\text{m/s}^2$. How long after the bus starts to move will the man catch the bus? Assume that the motion of the man and the bus is along a straight road. The cross in Figure 1 illustrates the point where the man catches the bus.

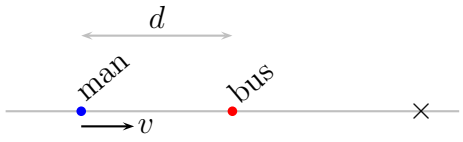

Figure 1: Problem 10.

[**Solution**, 2022F MT-01 P06]