Winter 2017

Physics 41 – Mechanics – Problem Set 2

Kinematics in One and Two Dimensions

- Written problems are due by 6:15 p.m. Fri., Jan. 20, uploaded to gradescope.
- The MasteringPhysics portion is due online by 6:15 p.m. Fri., Jan. 20.
- Review Chapter 2 and read 3.1–3.4 in Young & Freedman.
- **Practice Problems** in Young & Freedman: Ch. 2: 2.14, 2.22; Ch. 3: Q3.4, Q3.5, 3.7.

1. Brain injuries can be caused by strong linear acceleration of the head. Imaging measurements of a human head upon impact show that the magnitude of displacement of the brain relative to the skull is, at most, approximately 1mm, independent of the magnitude of the acceleration. Studies indicate that the probability of mild traumatic brain injury (MTBI) is approximately 25% for linear accelerations of the head of $50g$, where g is the acceleration due to gravity ($g = 9.8\frac{\text{m}}{\text{s}^2}$). The probability of MTBI is 100% for linear accelerations of $150g$.
For this problem, model the case of a bicycle accident as a human head falling straight down from rest at a height of 2 meters. Assume the ground is very hard and does not compress upon impact. Also assume constant deceleration of the brain upon impact.

(a) For the case when the cyclist is not wearing a helmet, what is the deceleration that the cyclist's head undergoes upon contact with the ground? Express your answer in $g's$. What is the probability of suffering a MTBI?

(b) Suppose you want to design a helmet that reduces the probability of MTBI to less than 25%. By how much must the helmet compress after impact to achieve this goal for our model assumptions? Express your answer in cm. Do typical bicycle helmets provide this amount of compression?

(c) Discuss ways in which our model (a human head falling straight down from rest at a height of approximately two meters onto an incompressible surface) could over- or under-estimate the probability of MTBI in a bicycle accident.

2. A water balloon is tossed straight up from the ground with initial speed v_b. After a time t_1, an arrow is shot straight up at the water ballon with speed v_a. You may neglect the effects of air resistance in this problem.

(a) In the absence of the arrow being shot, what is the maximum height that the water balloon would reach?

(b) Find an expression for the speed at which the arrow must be shot so that it hits the water balloon at the balloon's highest point. Is there a condition that must be satisfied by t_1 so that this is possible? Briefly explain.

(c) Draw qualitatively correct graphs for $y_b(t)$ (position of water balloon) and $y_a(t)$ (position of arrow) on the same set of axes (y versus t). Please indicate your choice of origin and direction for positive $\hat{j}$ (increasing y).

3. Young & Freedman (14th. ed), Problem 3.9, page 93.
A physics book slides off a horizontal tabletop with a speed of $1.10\,\frac{\text{m}}{\text{s}}$. It strikes the floor in $0.480\,\text{s}$. Ignore air resistance. Find:

(a) the height of the tabletop above the floor

(b) the horizontal distance from the edge of the table to the point where the book strikes the floor

(c) the horizontal and vertical components of book's velocity, and the magnitude and direction of its velocity, just before the book reaches the floor

(d) Draw $x - t$, $y - t$, $v_x - t$, and $v_y - t$ graphs for the motion.

4. Young & Freedman (14th. ed), Problem 3.10, page 93.
Please solve symbolically first, before substituting in numerical values. Let h be the height of the cliff above the ledge, and let w be the width of the ledge.

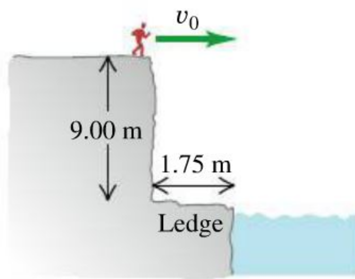

Figure 1: Figure E3.10 from Young and Freedman.

A daring 510 N swimmer dives off a cliff with a running horizontal leap, as shown in Fig. E3.10. What must her minimum speed be just as she leaves the top of the cliff so that she will miss the ledge at the bottom, which is 1.75 m wide and 9.00 m below the top of the cliff?

5. Please complete "Assignment 2" through MasteringPhysics at `masteringphysics.com`.