Physics 20 Problem Set 3

Harry Nelson

due Monday, October 18, by 5pm
to the Physics 20 Boxes in Broida Hall's Lobby

Course Info: The instructor is Harry Nelson, the TAs are Hyejin Ju and Yoni BenTov. A web page for the course is set up at http://hep.ucsb.edu/courses/ph20. Prof. Nelson how now scheduled his office hours... Fridays 12:00-2:00pm in 2712 Physical Sciences South.

We meet MWF 10:00-10:50am in 1640 Broida. There are **three discussion sections**, and attendance at the one you've registered for is mandatory.

The text for the course is 'An Introduction to Mechanics' by Kleppner and Kolenkow. (KK). This is a hard textbook, but rewarding. Our plan is to cover much of the first five chapters of this text. The 4th edition of Resnick, Halliday, and Krane 'Physics' (RHK4) has more detailed explanations of many topics, so is a good reference. Both texts are available in the library under Physics 20 reserve.

Working problems is crucial to the understanding of physics. Expect to spend at least 12 hours a week outside of class studying and working problems. It is good to work with other students to understand how to solve problems, but **write up your solutions independently and originally; don't copy other work and use it as your own, from another student or off the web... that is, well, cheating, with potentially dramatic penalties.**

Please make your work neat, clear, and easy to follow. It is hard to grade sloppy work accurately. Generally, make a clear diagram, and label quantities. Derive symbolic answers, and then plug in numbers after a symbolic answer is available.

These problems pertain to the third week's three lectures, and the corresponding reading is really Chapter 4 of RHK4, which is an expanded version of pages 13-14 in KK. The main topic is 2-dimensional kinematics and trajectories.

---

1. KK 1.13

2. A ball is dropped from a height of 39.0 m. The wind is blowing horizontally and imparts a constant acceleration of $1.2\,\mathrm{m/s^2}$ on the ball.

   (a) Show that the path of the ball is a straight line and find the values of R and θ in Fig. 1.

   (b) How long does it take for the ball to reach the ground?

   (c) With what speed does the ball hit the ground? (RHK4 4.10)

3. Refer to Fig. 2.

   (a) Prove that for a projectile fired from the surface of level ground with angle ϕ_0 above the horizontal, the ratio of the maximum height H to the range R is given by $H/R = \frac{1}{4}\tan\phi_0$.

   (b) Find the angle ϕ_0 at which the maximum height and the horizontal range are equal. (RHK4 4.21)

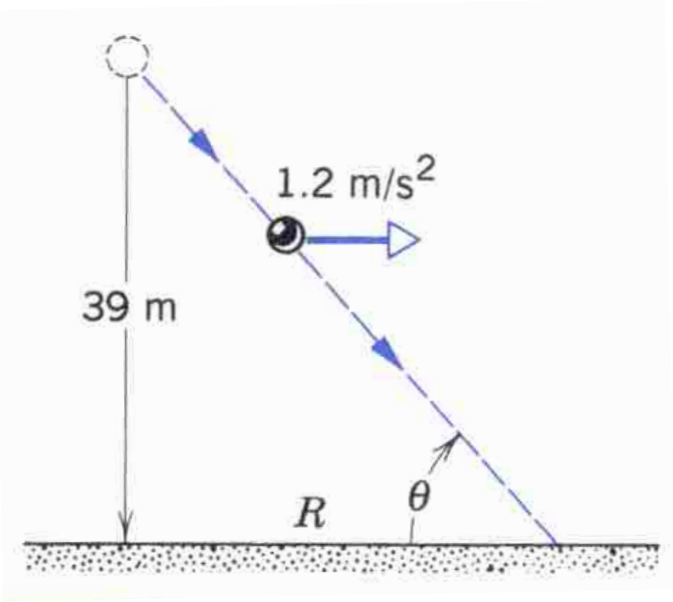

Figure 1: Problem 2a.

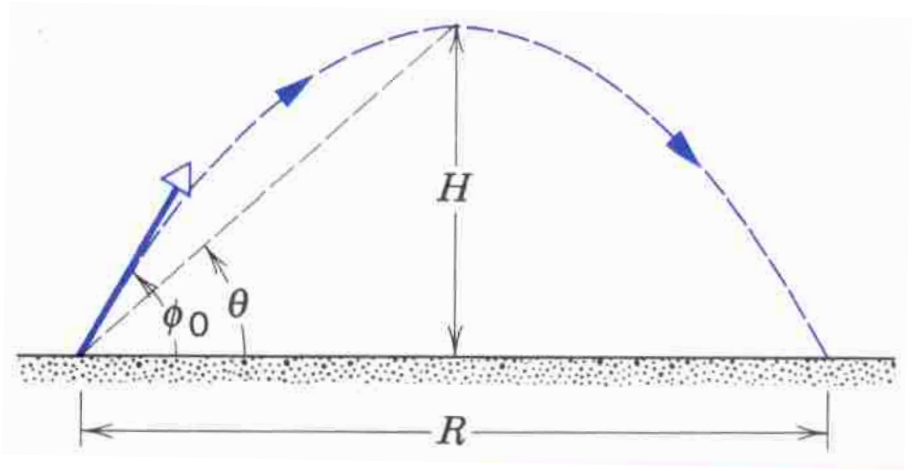

Figure 2: Problems 3 and 4.

4. Refer to Fig. 2. A projectile is fired from the surface of level ground with an angle ϕ_0 above the horizontal.

   (a) Show that the elevation angle θ of the highest point as seen from the launch point is related to ϕ_0 by $\tan\theta = \frac{1}{2}\tan\phi_0$.

   (b) Calculate θ for $\phi_0 = 45°$. (RHK4 4.22)

5. Refer to Fig. 3.

   (a) In Galileo's *Two New Sciences*, published in 1638, five years before the birth of Isaac Newton, the author states that "for elevations [angles of projection] which exceed or fall short of 45° by equal amounts, the ranges are equal." Prove this statement.

   (b) For an initial speed of 30 m/s and a range of 20 m, find the two possible elevation angles of projection. (RHK4 4.26)

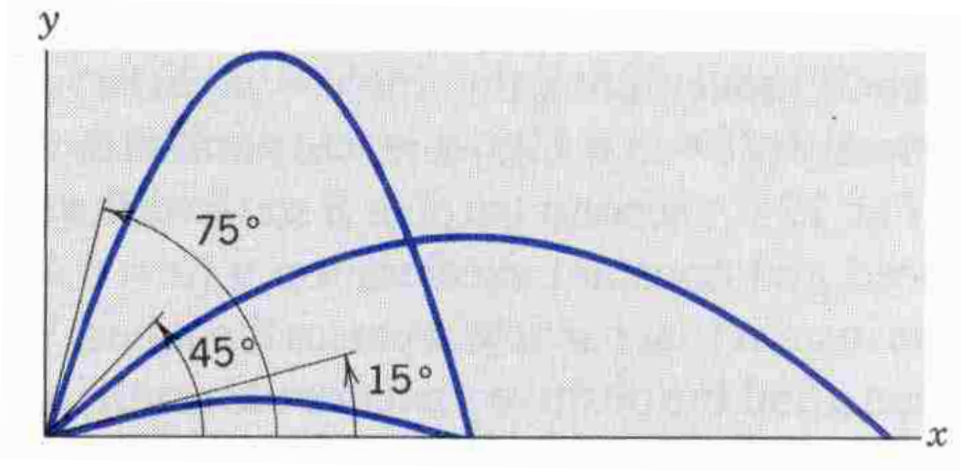

Figure 3: Problem 5.

6. A ball is thrown from the ground into the air. At a height of $h_0 = 9.1\,\text{m}$, the velocity is observed to be $\vec{v} = v_x\hat{\boldsymbol{\imath}} + v_y\hat{\boldsymbol{\jmath}}$, where $v_x = 7.6\,\text{m/s}$ and $v_y = 6.1\,\text{m/s}$. The x axis is horizontal and the y axis is vertical.

   (a) To what maximum height will the ball rise?

   (b) What will be the total horizontal distance traveled by the ball from start to hitting the ground?

   (c) What is the velocity of the ball (magnitude and direction) the instant before it hits the ground? (RHK4 4.30)

7. KK 1.21. Be careful, the definitions of θ and ϕ are a little different in KK than in RHK4. Add to this problem: What is the physical meaning of a $\phi < 0$? Plot the computed θ for maximum range versus ϕ for $-90° < \phi < 90°$ and interpret the graph.
