Oberlin College Physics 110, Fall 2011

Model Solutions to Sample Exam 1

Additional problem 11: *Watersheds.*

(a.) The Black River watershed is twice the size of the Vermilion River watershed. The two watersheds are "of similar geological and meteorological character," so it must have twice as much water falling into it. Thus it must have twice as much water pouring out of it: A discharge of twice 21 cubic feet per second, namely 42 cubic feet per second.

(b.) If the Black River were just two copies of the Vermilion River, it would have 82 miles of watercourse. But it's *not* just two copies. We've already seen that the Black River is "fatter" than the Vermilion — it has a greater discharge rate. There must be *less than* 82 miles of watercourse in the Vermilion watershed.

Additional problem 23: *Bouncing ball.*

The graph should resemble the one in your lab notebook. An appropriate (and appropriately brief) comment would be: "While the ball is not in contact with the floor, it is in freefall, that is: acceleration 9.8 $\mathrm{m/s^2}$ downward, velocity a straight line sloping downward, position a parabola bowing upward. For those brief moments when the ball touches the floor, the acceleration is very large and positive, and the velocity jumps up quickly."

Additional problem 29: *Jetliner takeoff.*

(a.) Connect velocity and position:

$$v^2 = v_0^2 + 2a_0(x - x_0).$$

So the "distance down the runway" is

$$x - x_0 = \frac{v^2}{2a_0} = \frac{(70\ \mathrm{m/s})^2}{2 \times 2\ \mathrm{m/s^2}} \approx 1200\ \mathrm{m}.$$

(b.) You can see that the runway length scales as the square of the takeoff speed, so the 7J7 would require runways four times as long.

Additional problem 30: *Rain speed.*

Connect velocity and position:

$$v^2 = v_0^2 + 2a_0(y - y_0).$$

In this case $v_0 = 0$, $a_0 = -g$, $y = 0$, and $y_0 = 6 \times 10^3$ m. So

$$v = \sqrt{2gy_0} = \sqrt{12 \times 10^4\ \mathrm{m^2/s^2}} \approx 350\ \mathrm{m/s}.$$

This is greater than the speed of sound! The approximation of "neglect air resistance" is clearly a poor one.

The exam will have four problems, but if you want still more practice, try these:

Additional problem 36: *Falling brick.*
Connect velocity and position:

$$v^2 = v_0^2 + 2a_0(y - y_0).$$

For stage I, the brick falling from height h, we have an impact velocity v_I where $v_I^2 = 2gh$. For stage II, the compressing pillow, we have

$$0 = v_I^2 + 2a_0(-\text{compression amount})$$

so

$$a_0 = \frac{v_I^2}{2(\text{compression amount})} = \frac{gh}{\text{compression amount}} = g\frac{9.0\text{ m}}{0.141\text{ m}} = 64g = 630\text{ m/s}^2.$$

Additional problem 45: *Fire tower.*
Solved in the handout packet.