Solutions to Sample Midterm Exam Problems, Phyx 135-1, Fall 2009

1) It will take the student $d = \frac{1}{2} gt^2$ seconds to reach the ground. This means $t = (2d/g)^{1/2} = (2 \times 35 / 9.8)^{1/2} = 2.67$ s. In that time, she will move $x = vt = (1.5)(2.67) = 4$ m from the window.

2) For a flat track, the maximum frictional force that can act to hold the car to the track is $F = \mu N = \mu mg$. The "centrifugal force" that the car experiences relative to the track is $F = mv^2/r$, so equating these gives $\mu mg = mv^2/r$, or $v = (\mu gr)^{1/2} = (0.5 \times 9.8 \times 75)^{1/2} = 19.2$ m/s.

3) The total energy generated by the solar panel is $(1300 \text{ W/m}^2)(4.5 \text{ m}^2)(60 \text{ s}) = 351{,}000$ J. This is converted into the kinetic energy of the car, so $v = (2E/m)^{1/2} = (2 \times 351{,}000 / 580)^{1/2} = 34.8$ m/s.

4) The force acting on the safe in the y-direction is $F_Y = (1200 \text{ kg})(0.6 \text{ m/s}^2) = 720$ N. This must be provided by the y-axis tensions in the cords, so $T_A \cos(50°) + T_B \cos(30°) = 720$ N. The safe has no x-axis acceleration, so the x-axis tensions in the cords must be equal: $T_A \sin(50°) = T_B \sin(30°)$. From this we derive $T_A = (0.5 / 0.766)T_B = 0.6527\ T_B$. Substitution into the y-axis equation yields $(0.6527)T_B(0.6428) + (0.866)T_B = 720$, or $T_B = 560$ N. Then $T_A = (560)(0.6527) = 365.6$ N.

5) From action-reaction, we know the top mass (9 kg) will have 1000 N of force pushing it in the positive y-direction. The distance it moves is $d = \frac{1}{2} at^2 = \frac{1}{2} (F/m)t^2 = \frac{1}{2} (1000 / 9)(0.2)^2 = 2.2$ m. Likewise, the right-hand mass will move $d = \frac{1}{2} (F/m)t^2 = \frac{1}{2} (2000 / 2.5)(0.2)^2 = 16$ m to the right. The central mass (1.2 kg) will move $d = \frac{1}{2} (F/m)t^2 = \frac{1}{2} (2000 / 1.2)(0.2)^2 = 33.3$ m to the left, and $d = \frac{1}{2} (F/m)t^2 = \frac{1}{2} (1000 / 1.2)(0.2)^2 = 16.7$ m down. The final coordinates for each mass are:

9 kg	(0.0, 3.2)
1.2 kg	(–33.3, –16.7)
2.5 kg	(18.0, 0.0)

6) E. The horizontal (x-axis) speed of a projectile is constant.

7) B. Gravity always has a constant, nonzero acceleration, which eliminates all the answers except B and F. The ball has no velocity at the top of its trajectory, so B is correct.

8) E. Gravity always provides a constant acceleration, regardless of mass. (See Question #7.)

9) A. If the elevator is not accelerating, then her weight is just what it would be if she were standing still. W = (60 kg)(9.8 m/s2) = 588 N.

10) C. The acceleration of a rotating object always points to the center of the circle.

11) D. We have $F = 200 \text{ N} = mv_1^2/r$, where $v_1 = 12$ m/s. We also have $F = 800 \text{ N} = mv_2^2/r$, where v_2 is what we want to know. Dividing one equation by the other: $4 = (v_2/v_1)^2$, so $v_2 = 2v_1 = 24$ m/s.