Problem Set 2

Instructions:

1. Answer all questions below. Show your work for full credit.
2. The first problem is due at the start of class on 24 Jan 2014
3. The second problems are due at the start of class on 27 Jan 2014
4. The remaining problems are due by the end of the day on 29 Jan 2014
5. You may collaborate, but everyone must turn in their own work.

Daily problem due 24 Jan 2014

1. A car is traveling at a constant velocity of 35 m/s and passes a stopped police cruiser. Exactly 2.5 s after passing, the cruiser begins pursuit, with a constant acceleration of $2.5\,\mathrm{m/s^2}$. How long does it take for the cruiser to overtake the car (from the moment the cop car starts moving)?

Daily problem due 27 Jan 2014:

2. *HRW 5.31* A block is projected up a frictionless inclined plane with an initial speed of $v_o = 2.50\,\mathrm{m/s}$. The angle of incline is $\theta = 17.0°$. (a) How far up the plane does the block go? (b) How long does it take to get there? (c) What is its speed when it gets back to the bottom?

The problems below are due by the end of the day on 29 Jan 2014.

3. A projectile is launched with initial velocity $\vec{\mathbf{v}}_i$ from the start of a ramp, with the ramp making an angle φ with respect to the horizontal. The projectile is launched with an angle $\theta > \varphi$ with respect to the horizontal. **(a)** At what position along the ramp does the projectile land? **(b)** What angle θ maximizes the distance the particle makes it along the ramp (your answer will be in terms of the angle φ? Note no numeric solution is required.

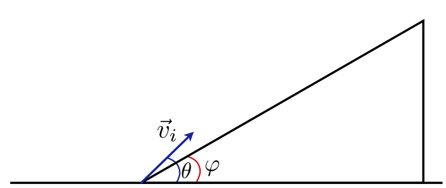


Figure 1: *A projectile is launched onto a ramp.*

4. A mass m is released from rest at height h on the top of a ramp of inclination θ. The coefficient of kinetic friction between the ramp and mass is μ_k. The block slides down the ramp, up a second identical ramp, back down again, and so forth.

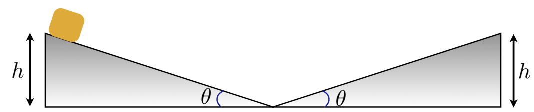


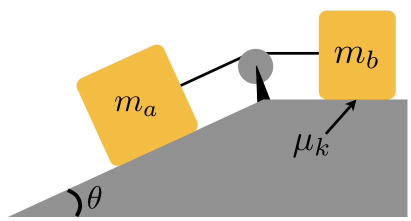
Figure 2: *A block is let go from the top of a ramp sitting on a table.*

(a) After one round trip (from the top of the first ramp and back again), how far away from the mass from its starting point?

(b) How about after n round trips?

(c) Does the mass ever stop?

5. *HRW 5.57* A block of mass $m_a = 3.70\,\text{kg}$ on a frictionless plane inclined at an angle $\theta = 30.0°$ is connected by a cord over a massless, frictionless pulley to a second block of mass $m_b = 2.30\,\text{kg}$ (figure below). What are (a) the magnitude of the acceleration of each block, (b) the direction of the acceleration of the hanging block, and (c) the tension in the cord?



6. A particle of mass m is subjected to the following force:

$$F(v) = a - bv \tag{1}$$

where a and b are positive constants with appropriate units, and v is the magnitude of the velocity.

(a) Find an expression for the velocity of the particle as a function of time in terms of a, b, m, and the initial velocity $v_o \geq 0$. Express the velocity in the limit $t \to \infty$ in terms of these same quantities.

(b) Find an expression for the position of the particle as a function of time in terms of a, b, m, v_o, and the initial position x_o.

(c) If the particle starts at rest, how far does it travel before its velocity is one half its maximum velocity?

7. *HRW 6.30* A toy chest and its contents have a combined weight of 180 N. The coefficient of static friction between toy chest and floor is $\mu_s = 0.42$. A child attempts to move the chest across the floor by pulling on an attached rope. (a) If the rope makes an angle of $\theta = 42°$ with the horizontal, what is the magnitude of the force $\vec{\mathbf{F}}$ that the child must exert on the rope to pull the chest on the verge of moving? (b) Write an expression for the magnitude F required to pull the chest on the verge of moving as a function of the angle θ. Determine the value of θ for which F is (c) a minimum and (d) a maximum magnitude.

8. A point mass m starts from rest from the top of a stationary sphere of radius R and slides down the frictionless surface. **(a)** At what angle θ (measured with respect to the vertical) does the mass fly off the sphere? **(b)** If there is friction between the mass and the sphere, does the mass fly off at a greater or smaller angle as the one found in part (a)? Explain your reasoning. An explicit calculation is not necessary if a good physical argument can be put forth.