Physics 7AW Homework 5 — The Force Awakens

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Physics 7AW - WAT 2020 edition

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After a recent update this homework has been heavily nerfed because physics is OP

Exercise 1. We have seen that in the absence of air resistance Newton's second law is simply $F = ma = mg$ for free-falling objects. When we consider air resistance and assume the drag force caused by the air is linearly proportional to the speed at which you fall the equation becomes:

$$F = ma = mg - kv \tag{1}$$

where k is a positive constant. Find an equation for velocity at a time t.

Hint: $\int \frac{du}{au+b} = \frac{1}{a} ln(au + b) + c$

Exercise 2. Recall Newton's law of gravity between two objects of mass m and M separated by a distance R^2 is

$$F = \frac{GMm}{R^2} \tag{2}$$

where $G = 6.67 \times 10^{-11} m^3 kg^{-1} s^{-2}$

When we take M to be the mass of the Earth ($M = 5.972 \times 10^{24} kg$) and an object of interest with mass m on the surface of Earth:

a) Solve for the radius R of the Earth.

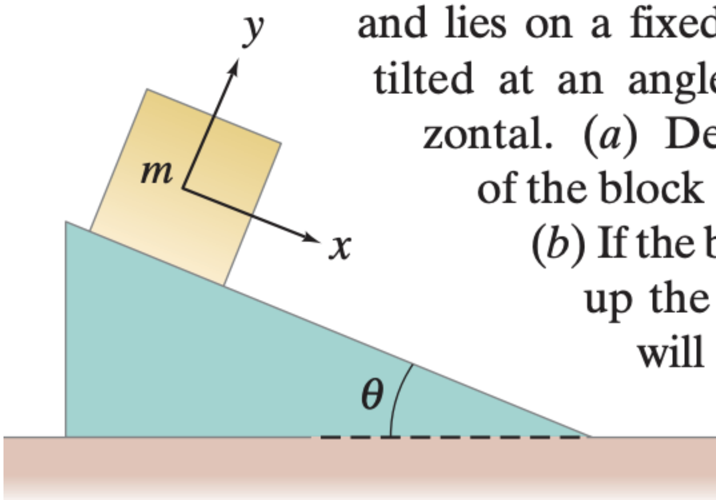
Remark **:** You may be wondering how someone would ever measure the mass of the Earth. Actually, it is much easier to approximate the radius of the Earth and then use the formula above to calculate M

b) (optional) As mentioned in class, this formula suggests that going further away from the center of the Earth reduces the force you feel, but yet we still use $F = mg$ whether you're on the ground or jumping off a plane. Let $F_0 = \frac{GMm}{R^2}$ be the force you feel on the *surface* of the Earth, and let $F_1 = \frac{GMm}{(R+\epsilon)^2}$ be the force you feel a distance $\epsilon > 0$ above the Earth's surface.
Question: How big does ϵ have to be (in meters) so that there's a 2% difference between F_0 and F_1? Assume that $\epsilon^2 = 0$ (this just means it is so small that we can neglect it. This does NOT mean $\epsilon = 0$)

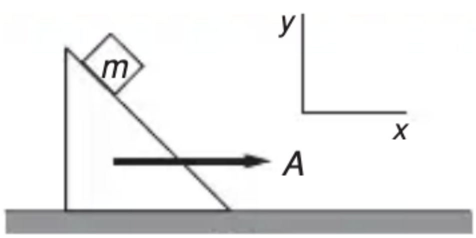
Hint: When does $\frac{F_1}{F_0} = .98$? Actually, g decreases by roughly 1 part per million for each increase in altitude of 3 m

Exercise 3. The problem is this photo:

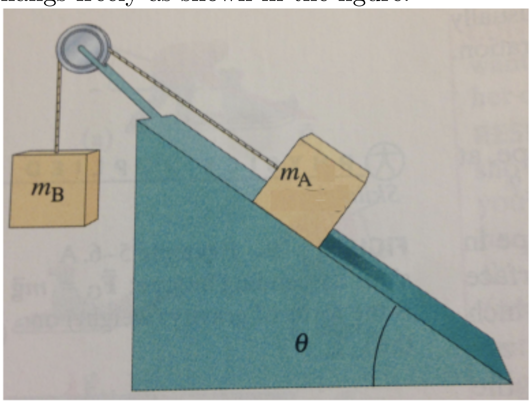
57. (II) The block shown in Fig. 4–59 has mass $m = 7.0\,\text{kg}$ and lies on a fixed smooth frictionless plane tilted at an angle $\theta = 22.0°$ to the horizontal. (*a*) Determine the acceleration of the block as it slides down the plane. (*b*) If the block starts from rest 12.0 m up the plane from its base, what will be the block's speed when it reaches the bottom of the incline?



Exercise 4. A θ °wedge is pushed along a table with constant acceleration A. A block of mass m slides without friction on the wedge. Find the block's acceleration.



Exercise 5. A box of mass m_A rests on a surface inclined at an angle θ to the horizontal. It is connected by a massless cord, which passes over a massless and frictionless pulley, to a second box of mass m_B, which hangs freely as shown in the figure.



Find the acceleration of m_A and m_B

Exercise 6. The two blocks M_1 and M_2 shown in the sketch are connected by a string of negligible mass. If the system is released from rest, find how far block M_1 slides in time t. Neglect friction.