When physicists have kids...

PHYS 1050 Tutorial 2

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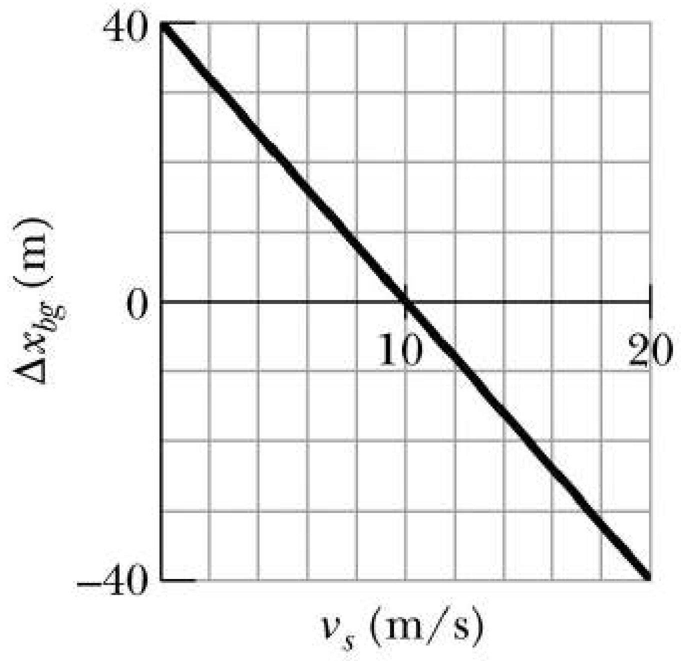
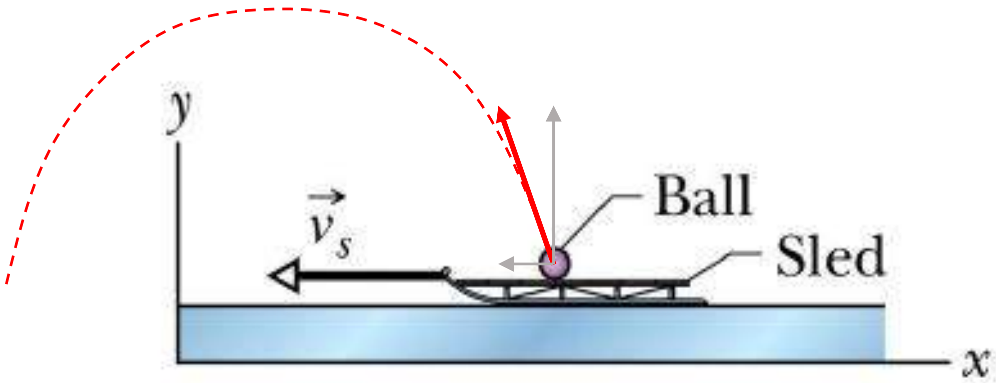
1) In the figure below at left, a sled moves in the negative x direction at constant speed v_s while a ball of ice is shot from the sled with a velocity $\vec{v}_0 = v_{0x}\hat{i} + v_{0y}\hat{j}$ relative to the sled. When the ball lands, its horizontal displacement Δx_{bg} relative to the ground (from its launch position to its landing position) is measured. The figure below at right gives Δx_{bg} as a function of v_s. Assume the ball lands at approximately its launch height. What are the values of (a) v_{0x} and (b) v_{0y}? The ball's displacement Δx_{bg} relative to the sled can also be measured. Assume that the sled's velocity is not changed when the ball is shot. What is Δx_{bs} when v_s is (c) 5.0 m/s and (d) 15 m/s?





Time it take to retouch ground

$$v_{0y}t - \frac{1}{2}gt^2 = 0$$

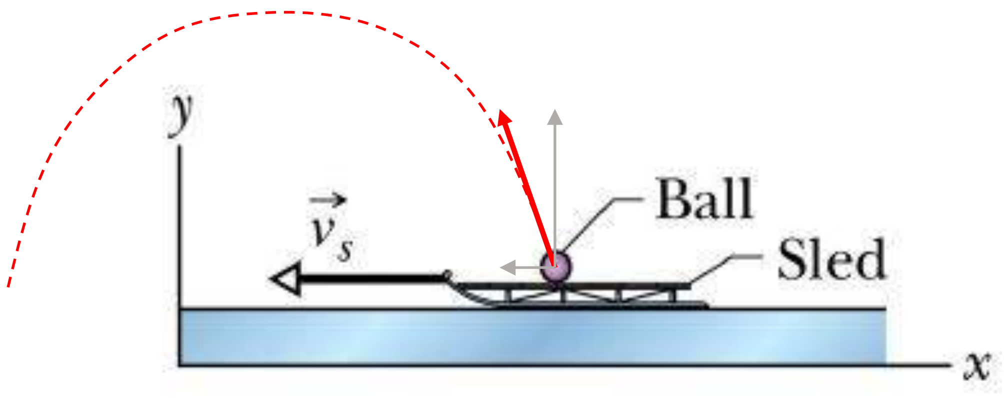
$$t = \frac{2v_{0y}}{g}$$

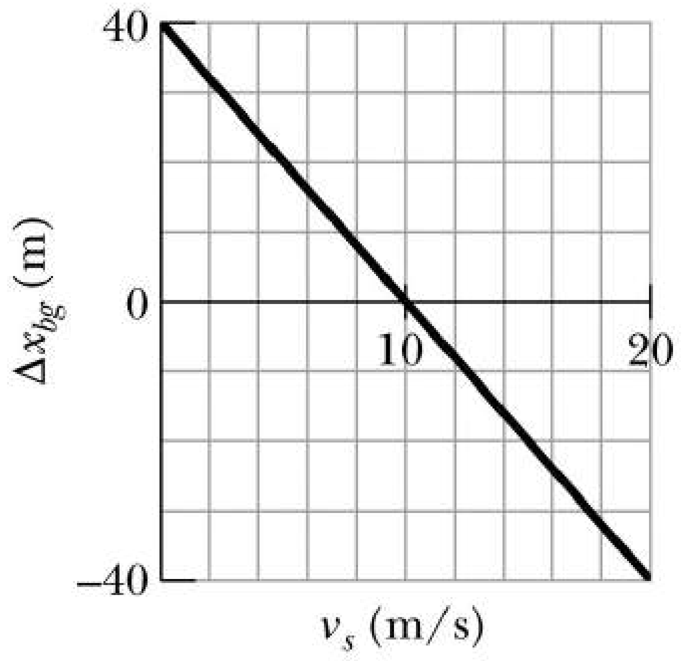
Displacement relative to ground

$$\Delta x_{bg} = (v_{ox} - v_s)t$$

The ball's velocity relative to ground :

$$\vec{v}_{0g} = (v_{0x} - v_s)\hat{\imath} + v_{0y}\,\hat{\jmath}$$





(a,b) So we have

$$\Delta x_{bg} = (v_{ox} - v_s)\frac{2v_{0y}}{g}$$

$$\Delta x_{bg} = 40 - 4 \times v_s$$

$$\frac{2v_{0y}}{g} = 4 \qquad v_{0y} = 2g = 20\, m/s$$

$$\frac{2v_{ox}v_{0y}}{g} = 40 \qquad v_{ox} = \frac{v_{ox}}{v_{0y}g} = \frac{20g}{2g} = 1g = 10\, m/s$$

(c,d) we have

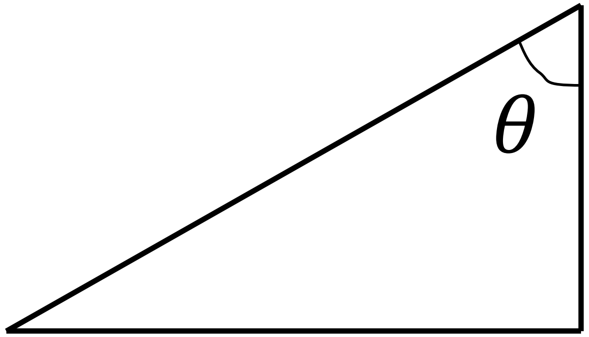
$$\Delta x_{bs} = (v_{ox})\frac{2v_{0y}}{g} = 40\, m$$

This does not depend on velocity of sled v_s

2) Snow is falling vertically at a constant speed of 8.0 m/s. At what angle from the vertical do the snowflakes appear to be falling as viewed by the driver of a car traveling on a straight, level road with a speed of 50 km/h?

$1h = 60\min \times 60s/\min = 3{,}600\ s$

$$v = \frac{50{,}000\ m}{3{,}600\ s} = 13.89\ m/s$$

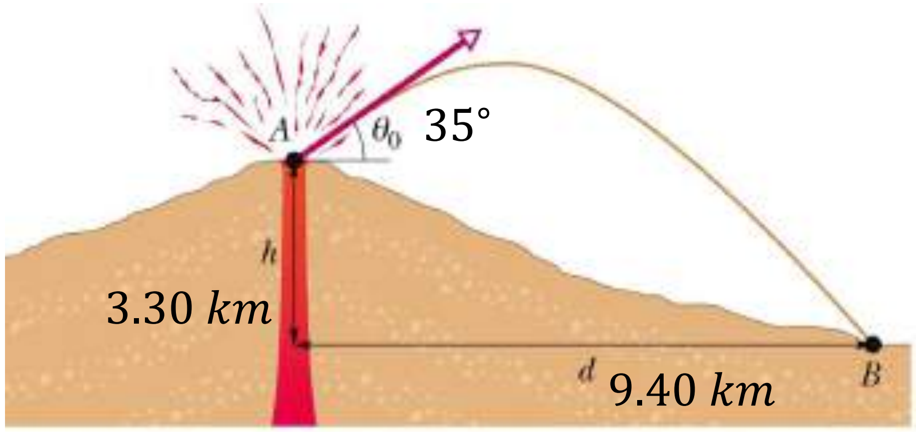


$v = 8.0\ m/s$

$v = 50km/h$

$$\theta = \arctan\frac{13.89}{8} = 60.06^{\circ}$$

3) During volcanic eruptions, chunks of solid rock can be blasted out of the volcano; these projectiles are called *volcanic bombs*. The figure above shows a cross-section of Mt. Fuji, in Japan. (a) At what initial speed would a bomb have to be ejected, at an angle of $\theta_0 = 35°$ to the horizontal, from the vent at A in order to fall at the foot of the volcano at B, at vertical distance $h = 3.30$ km and horizontal distance $d = 9.40$ km? Ignore, for the moment, the effects of air on the bomb's travel. (b) What would be the time of flight? (c) Would the effect of the air increase or decrease your answer in (a)?



(a)

$$v_{0x} = v_0 \cos\theta_0 \qquad x = v_{0x} t$$

$$v_{0y} = v_0 \sin\theta_0 \qquad y = v_{0y}\frac{x}{v_{0x}} - \frac{1}{2} g\left(\frac{x}{v_{0x}}\right)^2$$

$$y = x\tan\theta_0 - \frac{g x^2}{2(v_0\cos\theta_0)^2}$$

$$x = 9400\ m$$
$$y = 3300\ m$$

$$v_0 = \frac{x}{\cos\theta_0}\sqrt{\frac{g}{2(x\tan\theta_0 - y)}} \approx 255 m/s$$

(b)

$$t = \frac{x}{v_{0x}} = \frac{9400\ m}{255 m/s \cos 35°} = 45\ s$$

(c)

$$F_{air} = c \cdot A \cdot v^2$$

$v_{air} < v_{0x}$ $\quad$ Or $\quad$ $v_{air} > 0$

Makes the v_0 increase

$v_{air} > v_{0x}$

Makes the v_0 decrease


4) The fast French train known as the TGV (Train á Grande Vitesse) has a scheduled average speed of 216 km/h. (a) If the train goes around a curve at the speed and the magnitude of the acceleration experienced by the passengers is to be limited to 0.050 g, what is the smallest radius of curvature for the track that can be tolerated? (b) At what speed must the train go around a curve with a 1.00 km radius to be at the acceleration limit?

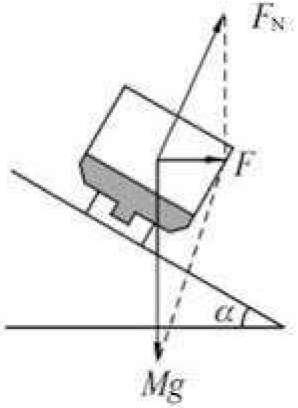
(a)

$$v = \frac{216\,000\ m}{3600\ s} = 60\ m/s$$

$$a = \frac{v^2}{r} = 0.05\ g \qquad r = \frac{v^2}{0.05\ g} = \frac{(60 m/s)^2}{0.05 \times 10\ m/s^2} = 7200\ m$$

(b)

$$v = \sqrt{ar} = \sqrt{0.05g\ 1000m} \approx 22.36 m/s = 80.5\ km/h$$



Fastest Trains in the World

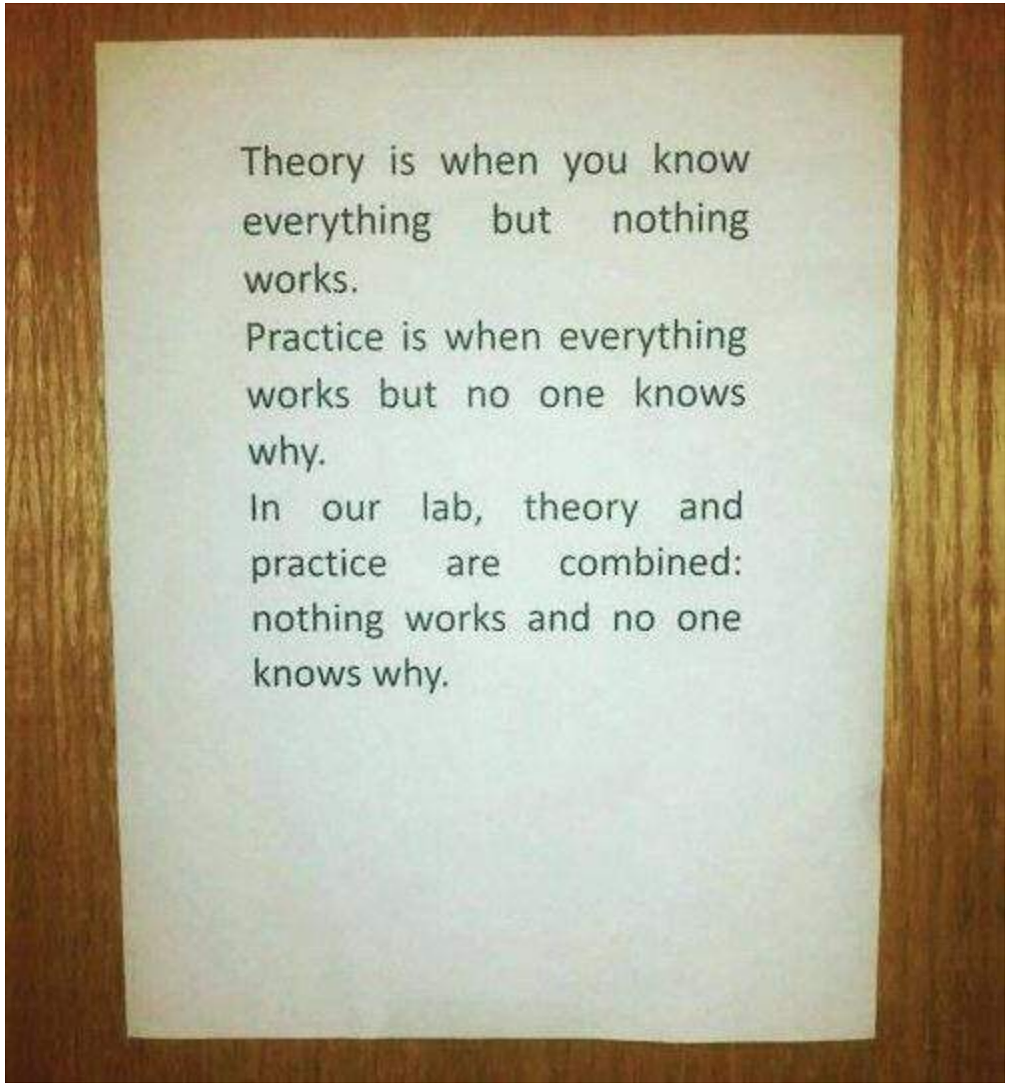
1. Shanghai Maglev: 267 mph = 430 km/h

The world's fastest train isn't the newest, the shiniest, or even the one with the most expensive tickets. Charging $8 per person, per ride, the Maglev runs the nearly 19 miles from Shanghai's Pudong International Airport to the Longyang metro station on the outskirts of Shanghai. That's right—the train, which takes just over 7 minutes to complete the journey using magnetic levitation (maglev) technology, doesn't go to the city center. As such, the bulk of the passengers since its 2004 debut have been travelers on their way to and from the airport, cameras out and ready to snap a photo of the speed indicators when the train hits 431 km/hr (267 mph).

2. Fuxing Hao CR400AF/BF: 249 mph = 400 km/h

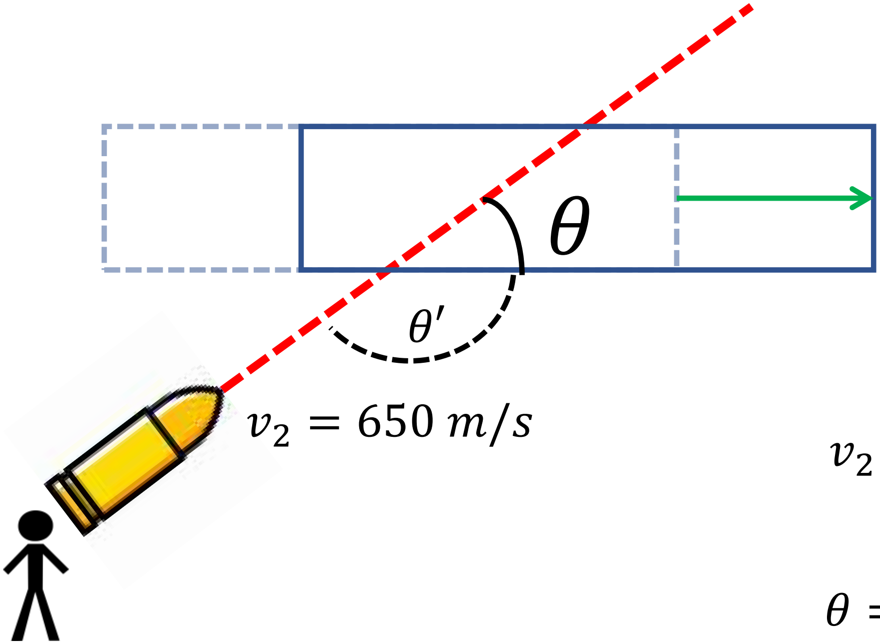
China wins again, also serving as home to the world's fastest non-maglev train currently in service. The name "Fuxing Hao" translates to mean "rejuvenation," and each of the two trains have been branded with nicknames: CR400AF is "Dolphin Blue," and the CR400BF is "Golden Phoenix." The "CR" stands for China Railway. Both take just under five hours to zip up to 556 passengers each between Beijing South and Shanghai Hongqiao Station, easily halving the nearly 10-hour time it takes to ride the conventional, parallel rail line between these two megalopolises. The "Rejuvenation" also beats China's next fastest train, the "Harmony" CRH380A; it has dazzled since 2010, with speeds of up to 236 mph on routes connecting Shanghai with Nanjing and Hangzhou, and Wuhan with Guangzhou.

Bullet Trains


Theory is when you know everything but nothing works.
Practice is when everything works but no one knows why.
In our lab, theory and practice are combined: nothing works and no one knows why.


Theory
Practice

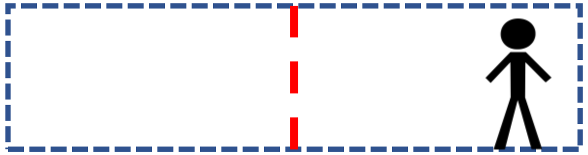
5) A wooden boxcar is moving along a straight railroad track at speed v_1. A sniper fires a bullet (initial speed v_2) at it from a high-powered rifle. The bullet passes through both lengthwise walls of the car, its entrance and exit holes being exactly opposite each other as viewed from withing the car. From what direction, relative to the track, is the bullet fired? Assume that the bullet is not deflected upon entering the care, but that its speed decreases by 20%. Take $v_1 = 85$ km/h and $v_2 = 650$ m/s. (Why don't you need to know the width of the boxcar?)



$v_2 = 650\ m/s$

$v_1 = 80\ km/h$

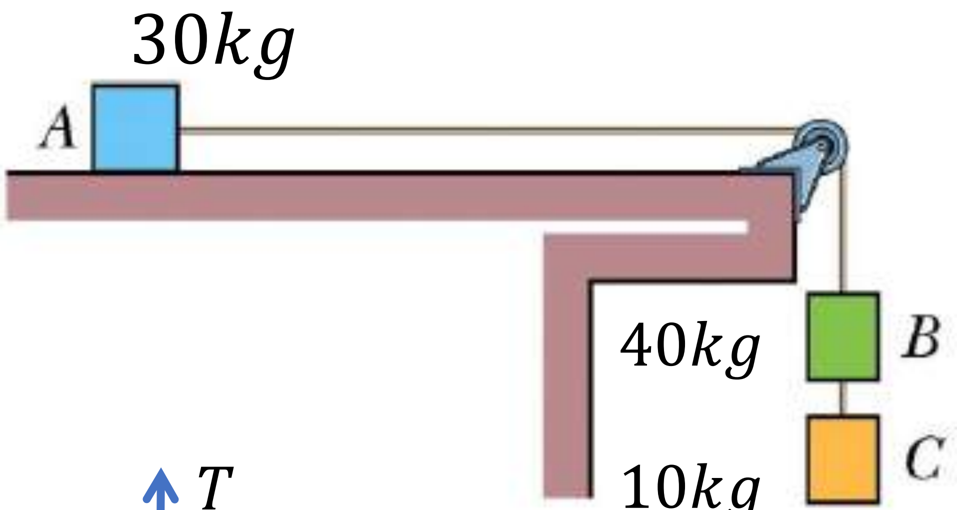
$v_1 = 23.61\ m/s$



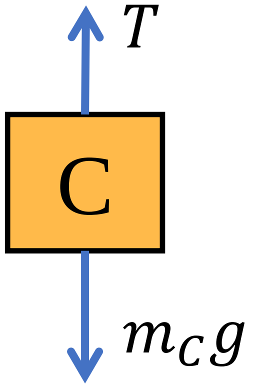
$$v_2 \times 80\% \cos\theta = v_1$$

$$\theta = \cos^{-1}\frac{v_1}{0.8 \times v_2} = \cos^{-1}\frac{23.61}{0.8 \times 650} = 87^\circ$$

$$\theta' = 180^\circ - 87^\circ = 93^\circ$$



6) In the figure above, three ballot boxes are connected by cords, one of which wraps over a pulley having negligible friction on its axle and negligible mass. The three masses are $m_A = 30.0$ kg, $m_B = 40.0$ kg and $m_C = 10.0$ kg. When the assembly is released from rest, (a) what is the tension in the cord connecting B and C, and (b) how far does A move in the first 0.250 s (assuming it does not reach the pulley)?



(a)

$$(m_B + m_C)g = (m_A + m_B + m_C)a$$

$$a = \frac{(m_B + m_C)}{(m_A + m_B + m_C)} g = \frac{5}{8} g$$

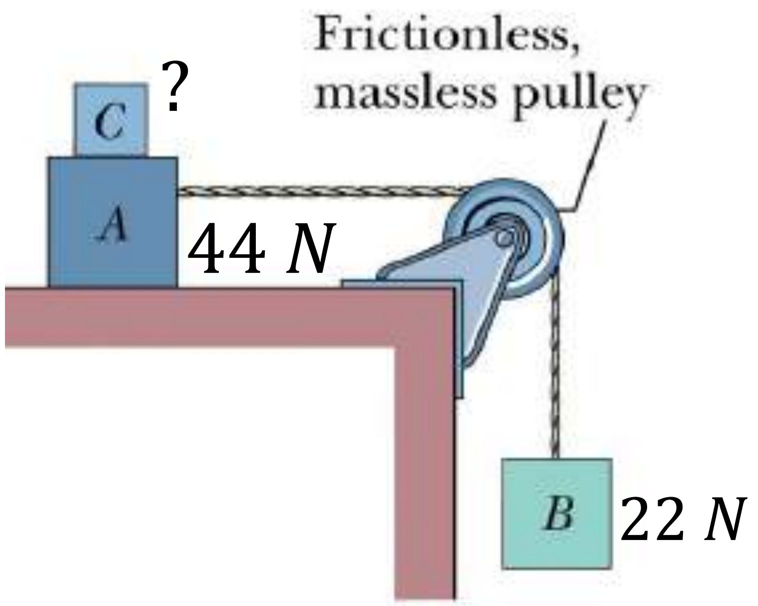
$$T - m_C g = -m_C a$$

$$T = m_C g - m_C a = \frac{3}{8} m_C g = 37.5\ N$$

(b)

$$x = \frac{1}{2} a t^2 = \frac{5}{16} \times 10 \times (0.25)^2 = 0.1953\ m$$

7) In the figure above, blocks A and B have weights of 44 N and 22 N, respectively. (a) Determine the minimum weight of block C to keep A from sliding if μ_s between A and the table is 0.20. (b) Block C suddenly is lifted off A. What is the acceleration of block A if μ_k between A and the table is 0.15?



(a)

$$\mu_s(m_A + m_C)g = m_B g$$

$$m_c g = \frac{m_B g \; - \mu_s m_A}{\mu_s} = \frac{22N \; - 0.2 \times 44N}{0.2} = 66N$$

(b)

$$(m_A + m_B)a = m_B g \; - \mu_s m_A g$$

$$a = \frac{m_B g \; - \mu_s m_A g}{m_A + m_B} = \frac{22N - 0.15 \times 44N}{22N + 44N} = 0.233g = 2.3\, m/s$$


A PHOTON CHECKS INTO A HOTEL AND IS ASKED IF HE NEEDS ANY HELP WITH HIS LUGGAGE.
"NO, I'M TRAVELLING LIGHT."