Physics 2048C Test 2 Solutions   Dr. Jeff Saul
Fall 2001

Problem 1 (Short Answer: 20 points)

a.) E

b.) A

c.) E

d.) B

e.) G

f.) B

The key to this problem is understanding that for this problem, the applied force is the same as the net force and therefore points in the same direction and is proportional to the acceleration of the cart.

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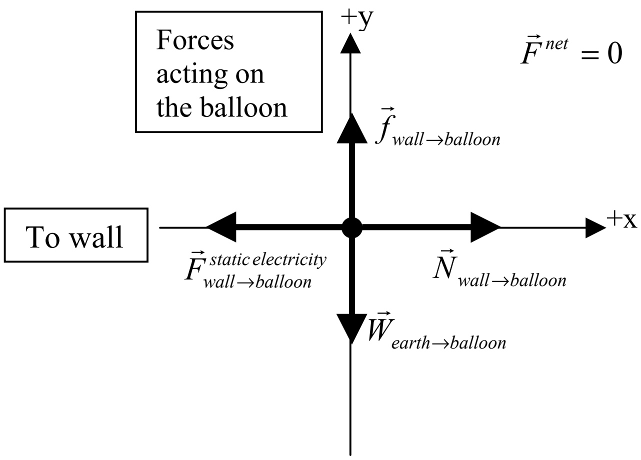
Problem 2 (Estimation: 10 points)

Based on a student solution:



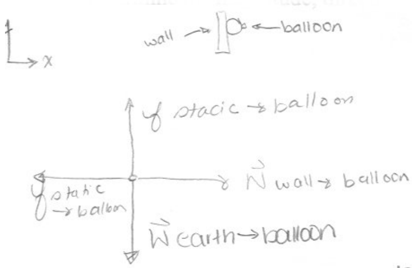
Desired unknown is the friction force between the wall and the balloon. This is what is keeping the balloon up.

Estimate a non-inflated balloon weighs 2 grams – full of air may mass 1 more gram
Total mass = 3g
3g = 0.003 kg

Thus $\vec{W} = mg = (0.003\text{ kg})(9.8\text{ m/s2})$
$\vec{W} = -0.0294N\,\hat{j}$ (downward)

Since net force is zero, the two vertical forces must be equal in magnitude and opposite in direction, so
$\vec{f}_{wall \to balloon} = -\vec{W}_{earth \to balloon} = -(-0.0294N)\hat{j}$
$\vec{f}_{wall \to balloon} = 0.03N\,\hat{j}$

Comment: *Although the balloon is attracted to the wall by an electric force caused by static electricity, it is the friction force of the wall acting on the balloon that keeps the balloon from falling down. This problem is similar to the problem we did in class where we looked at what keeps a refrigerator magnet up.*



The force that is (in y-direction) holding up the balloon is a static-electricity force on the balloon. This is equal in magnitude to the weight of the earth on the balloon.

$|\vec{f}| = |\vec{w}|$

type: It is a friction force.

magnitude: $|\vec{f}_{static \to balloon}| = |\vec{w}_{earth \to balloon}|$

direction: upward

$\vec{f} = -|\vec{w}|$

From another student solution: *This is a good solution. The only thing missing is the estimation of the mass and the calculation to determine the weight of the balloon to find the magnitude of the frictional force.*

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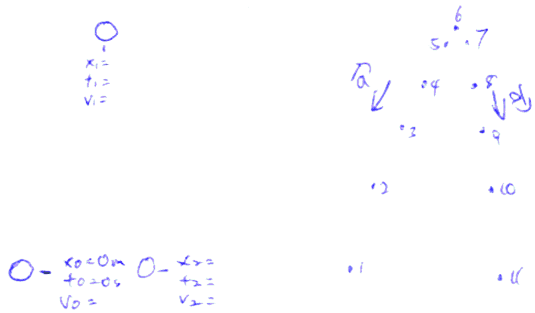
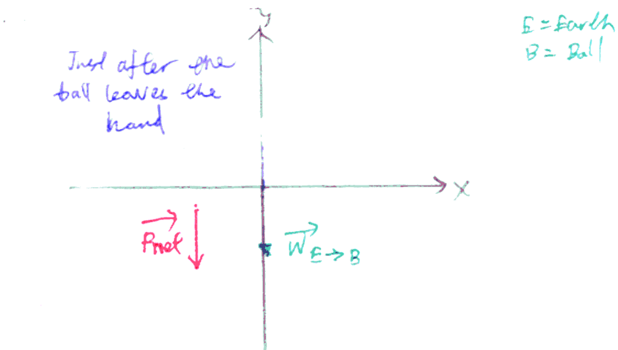
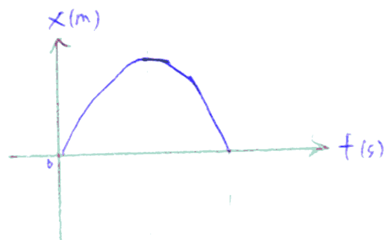
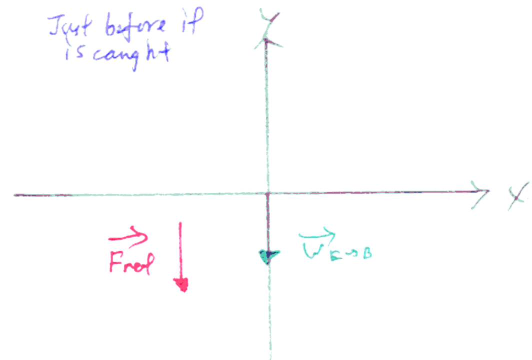
Problem 3 (Essay 10 points)
You may use words, diagrams, and equations but no calculations in your response for this problem.

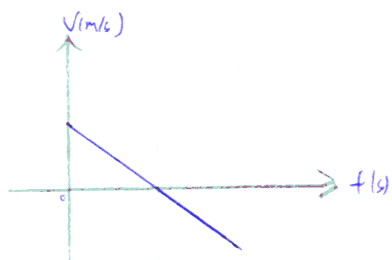
Recall that you were asked to assume that air resistance is negligible on this test.





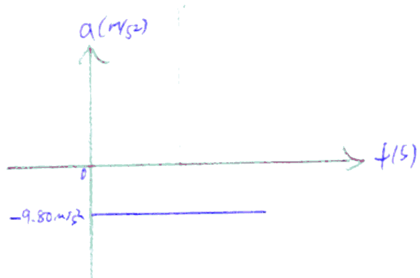




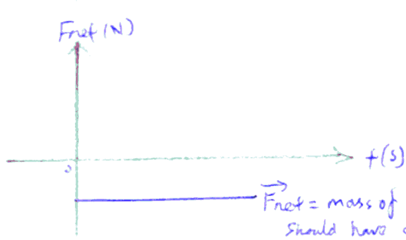


As the ball leave the bat, it move upward but with a decreasing velocity as the gravity of earth is acting on it.

At its highest pt, velocity = 0 m/s
It starts to fall back to earth increasing its speed($|\vec{v}|$) because the gravity of the earth is now in the same direction as the velocity, pointed downward.



While this is a good answer to the question of what happens to the ball between the time it is hit and when it is caught, it doesn't discuss the ball's motion in terms Newton's Laws of motion. It does have good graphs and free body diagrams.



$\vec{F}_{net}$ = mass of ball × acceleration
Should have a positive magnitude but pointing downward.

Problem 3 (cont.)

To be complete, a solution should mention the following points: According to Newton's 0^{th} law, objects only feel forces that act on the object at the moment in question. Thus once the ball leaves the bat, it forgets about the bat and only feels the gravitational force due to gravity from the earth. After the ball leaves the bat, the ball has an upward velocity. Between the time the ball is hit and when it is caught, by Newton's 1st law, since there is a net force there must be a change in the velocity of the ball. From Newton's 2^{nd} law, the acceleration of the ball equals the net force acting on the ball divided by the mass of the ball. Since the net force is equal the weight force, the magnitude of a = mg/m = g and the direction of a is downward in the direction of the net force. Thus a is downward and equal in magnitude to g for the entire time the ball is in the air between the time it is hit and when it is caught, even at maximum height when the velocity = zero m/s.

Comment: *While we can say that a ball has a downward acceleration, an acceleration cannot pull down on a ball. Pulling or pushing requires a force.*

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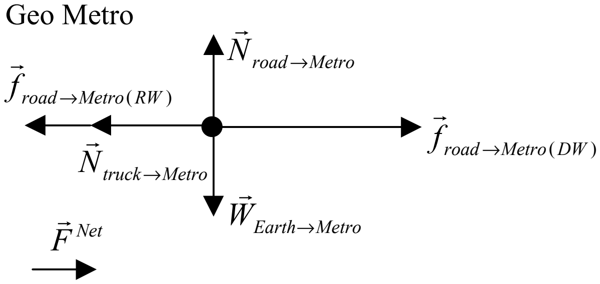
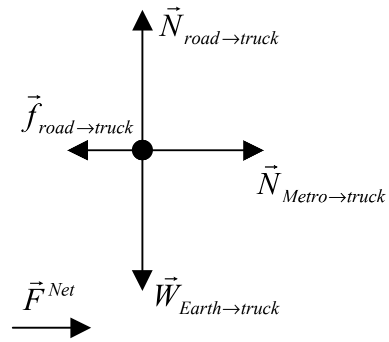
Problem 4 (15 points)

a. Free body diagrams

Geo Metro



Truck



Ranking the horizontal forces

Since the car and truck are accelerating to the right, we know from Newton's 2nd law of motion that the net force must also be to the right. Thus the sum of forces to the right must be greater than the sum of forces on the left. So

$$f_{road\rightarrow Metro(DW)} > \begin{matrix} N_{truck\rightarrow Metro} \\ f_{road\rightarrow Metro(RW)} \end{matrix} \quad \text{and} \quad N_{Metro\rightarrow truck} > f_{road\rightarrow truck}$$

The following forces are equal because they are a Newton's 3rd law pair

$N_{Metro\rightarrow truck} = N_{truck\rightarrow Metro}$

Since the car and the truck are moving, the resistive friction forces = μ N = μ W (For both the car and the truck vertical acceleration = zero, this implies that N = W for both vehicles.)

Since the mass of the truck is greater than the mass of the Geo Metro

$f_{road\rightarrow truck} > f_{road\rightarrow Metro(RW)}$

Therefore $f_{road\rightarrow Metro(DW)} > N_{truck\rightarrow Metro} = N_{Metro\rightarrow truck} > f_{road\rightarrow truck} > f_{road\rightarrow Metro(RW)}$

b. From a student paper:

$v_f = 20$ mph $\quad v_i = 0$ mph $\quad \Delta t = 5$ min $= .08\bar{3}$ hr

Looking for a so we can find Δs

$v_f = v_i + a\Delta t$

$a = \frac{v_f - v_i}{\Delta t} = \frac{20\text{ mph} - 0\text{ mph}}{.08\bar{3}\text{ hr}} = 240$ mph/h

$v_f^2 = v_i^2 + 2a\Delta s \qquad a = 240$ mph/h $\quad v_f = 20$ mph $\quad v_i = 0$ mph

$\Delta s = \frac{v_f^2 - v_i^2}{2a} = \frac{20^2\text{ mph} - 0^2\text{ mph}}{2(240\text{ mph/h})} = .8\bar{3}$ mi

Good solution to part b. Note how the student included the given information and what they were trying to find. Also note how the student started from the general equations and solved for the unknowns symbolically before substituting numbers with units.

Problem 4 (cont.)

c. From a student paper:

1000 N because since the truck was not moving the force must not have overcome the friction, However since the friction likewise is not pulling the truck back the sum of their forces is 0 (since 0 accel), so the friction must be = mag. and opposite direction

1000 N because since the truck is not moving, the force must not have overcome the friction, however since the friction likewise is not pulling the truck back (*since the truck is stationary*), the sum of their forces is zero (since 0 accel – *should cite Newton's 1st or 2nd law of motion here*) so the friction must be = mag. and opposite direction. (*Italics – comments by Dr. Saul*)

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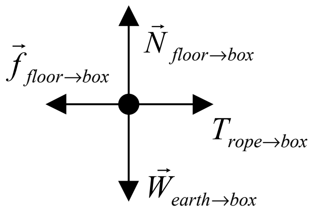
Problem 5 (20 points)

a. Need free body diagrams to see this. Since v = constant, $F^{net} = 0$ for both the rope and the crate (Newton's first law of motion). Let's assume that the magnitude of the tension in the rope is constant so that $T_{box \to rope} = T_{rope \to box} = T_{worker \to rope}$



$\vec{F}^{Net} = 0$

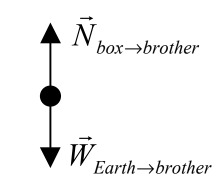
Since the net force = 0, the horizontal forces acting on the box add up to zero. Since there are only two of them, these two forces are equal in magnitude and opposite in direction. Thus, the force that the worker exerts is equal in magnitude and opposite in direction to the friction force exerted by the floor on the box. The magnitude of this friction force = $\mu N_{floor \to box}$. However, since the normal force is one of only two vertical forces acting on the box with the other force being the Weight force exerted by the Earth on the box, the two vertical forces are of equal magnitude. Therefore

$T_{worker \to rope} = f_{floor \to box} = \mu N_{floor \to box} = \mu W_{Earth \to box} = \mu mg$ and

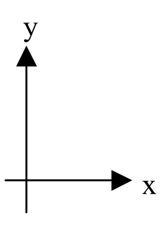
The force exerted by the worker on the rope points to the right.

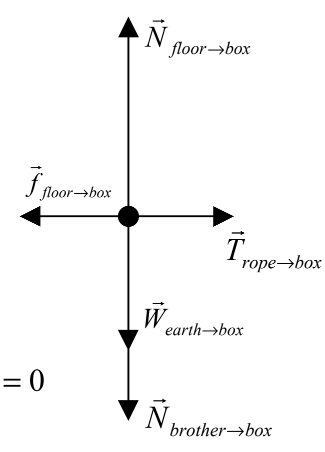
b. Yes, how hard the worker pulls does depend on whether or not her little brother is on top. As we showed above, how hard the worker pulls depends on the strength of the normal force exerted by the floor on the box. As we saw in the two-book problem in class, placing the little brother on top of the box increases the normal force the floor exerts on the box. Looking at the forces acting on the box, the net force on the box is zero since it is stationary and not moving. So the normal force of the floor on the box must be equal in magnitude to the weight force of the Earth on box plus the normal force of the little brother on the box. Since the weight force on the box has not changed, the normal force exerted by the floor on the box is larger than if the brother were removed. (See the free body diagrams in part c). This increases the frictional force exerted by the floor on the box, which means the worker must pull harder to keep the box moving with constant velocity.

c.



$\vec{F}^{Net} = 0$





$\vec{F}^{Net} = 0$

$\boxed{T_{wkr \to rope} = 300 \text{ N}}$

Since $\vec{F}^{Net} = 0$, then $F_x^{Net} = F_y^{Net} = 0$

For little brother,

$$0 = F_y^{Net} = \vec{N}_{y\ box \to brother} + \vec{W}_{y\ Earth \to brother}$$

$$\vec{N}_{y\ bx \to br} = -\vec{W}_{y\ E \to br} = -(-m_{br} g) = m_{br} g$$

From Newton's 3rd law of motion

$$\vec{N}_{y\ br \to bx} = -\vec{N}_{y\ bx \to br} = -m_{br} g$$

For the box

$$0 = F_y^{Net} = \vec{N}_{y\ f \to bx} + \vec{N}_{y\ br \to bx} + \vec{W}_{y\ E \to bx}$$

$$\vec{N}_{y\ f \to bx} = -\vec{N}_{y\ br \to bx} - \vec{W}_{y\ E \to bx}$$

$$\vec{N}_{y\ f \to bx} = -(-m_{br} g) - (-m_{bx} g) = (m_{br} + m_{bx}) g$$

$$T_{wrkr \to rope} = f_{fl \to bx} = \mu \left| \vec{N}_{y\ fl \to bx} \right| = \mu (m_{br} + m_{bx}) g$$

$$T_{wkr \to rope} = (0.4)\ [(30 \text{ kg}) + (50 \text{ kg})]\ (9.8 \text{ m/s}^2)$$