Extra Dynamics Problems in Preparation for the Test!!

Discussion/Application Problems:

1.Discuss how Newton's Laws can be used to explain the introduction of transportation safety features such as:

a) Head rests in cars

* See page 3

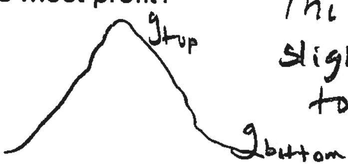
b) Seat belts in cars

* See page 3

c) Speed limits on curved ramps

* See page 3

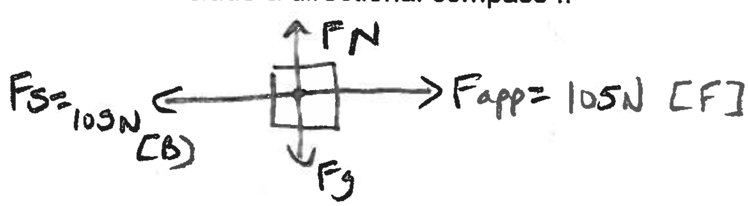
2.You are prospecting for gold in the mountains of Northern British Columbia and are paid by the weight of gold you find! Should you have your gold weighed on top of the mountain where you found it or at the bottom of the mountain? Which location would be most advantageous for your if you would like to earn the most profit?

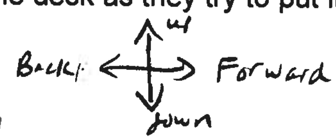


The gravitational field strength at the top of the mountain is slightly less than that at the bottom of the mountain as the top is farther from the centre of the Earth ($g = \frac{GM}{r^2}$). The weight of gold measured at the bottom will thus be slightly greater and it will be to your advantage to have it weighed at the bottom.

3. Two students wish to move a desk (mass 37.0 kg) across a flat horizontal floor. They need to apply a force of 105 N to ***just start*** the desk moving.

a) Draw a free-body diagram showing all forces acting on the desk as they try to put it into motion. Remember to include a directional compass !!





b) Determine the coefficient of static friction between the desk and the floor.

1) To just start the desk moving $F_s = F_{app}$

2) Vertical forces balanced $F_N = F_g = mg$

$F_s = \mu_s F_N$

$105N = \mu_s (37.0 kg)(9.81 N/kg)$

$\mu_s = \frac{105N}{(37.0kg)(9.81 N/kg)}$

$= 0.2893$

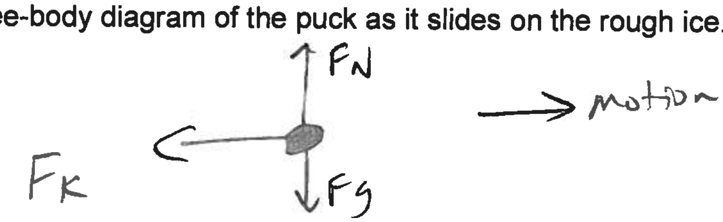
~ 0.289

c) If they continued to apply a force of 105 N once the desk is moving, would the desk maintain a constant velocity or would it accelerate? Explain your answer.

Since the coefficient of kinetic friction would be less than μ_s, the kinetic friction force would be less than the maximum static friction. Their applied force would thus exceed the frictional force, there would be a net force on the desk and it would accelerate.

4. Coyote and Roadrunner are taking a break from their chase to play a game of ice hockey out on a frozen pond. Coyote shoots the puck at Roadrunner giving the puck (mass 0.18 kg) an initial velocity of 15.5 m/s [forward]. It slides along on rough ice. Assume that the coefficient of kinetic friction between the puck and the rough ice is 0.42.

a) Draw a free-body diagram of the puck as it slides on the rough ice.



$m = 0.18 kg$

$V_i = 15.5 m/s$ [F]

$\mu_K = 0.42$

b)Find the force of kinetic friction acting on the puck.

$m = 0.18\ kg$ $\quad F_K = \mu_K F_N$

$\mu_K = 0.42$ $\quad = (0.42)(0.18\,kg)(9.81\ N/kg)$

$F_N = F_g = mg$ (∴ vertical forces balanced) $\quad = 0.742\ N$

∴ the frictional force is 0.742 N [Backwards]

c)Determine the average acceleration of the puck while on the rough ice.

$\vec{a} = ?$ $\quad F_{net} = m\vec{a}$

$$\vec{a} = \frac{F_{net}}{m} = \frac{0.742\,N\,[B]}{0.18\,kg} = 4.1\ m/s^2\ [B]$$

d)Find the final velocity of the puck when it reaches Roadrunner after travelling 23.0 m along the rough ice.

$\vec{v}_1 = 15.5\,m/s\,[F]$

$\Delta\vec{d} = 23.0\,m\,[F]$

$\vec{a} = 4.1\ m/s^2\ [B]$

$\vec{v}_2 = ?$

$$\Delta\vec{d} = \frac{v_2^2 - v_1^2}{2a}$$

$$v_2^2 - v_1^2 = 2a\Delta d$$

$$v_2^2 = v_1^2 + 2a\Delta d$$

$$v_2 = \sqrt{v_1^2 + 2a\Delta d}$$

$$v_2 = \sqrt{(15.5)^2 + 2(-4.12)(23.0)}$$

$$v_2 = \sqrt{50.728}$$

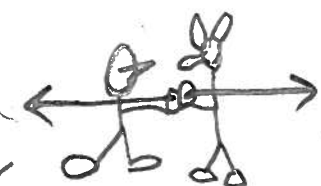
$$v_2 = 7.12\ m/s$$

∴ the final velocity is 7.1 m/s [F].

5. Coyote and Roadrunner get into an argument at the end of the game over who won! Roadrunner (mass 15.0 kg) pushes Coyote (mass 21.0 kg) with a force of 35.0 N [East]. Assume that they are initially at rest and are standing on a smooth patch of ice.

a) Draw a diagram showing the action and reaction forces between Coyote and Roadrunner. Please fully label all forces!!

F Coyote on Roadrunner [West]



F Roadrunner on Coyote [East]

b) Calculate the acceleration of each cartoon character.

$\vec{F}_{C\,on\,R} = 35.0\,N\,[W]$

$m_R = 15.0\ kg$

$\vec{a}_R = ?$

$$\vec{a}_R = \frac{F_{C\,on\,R}}{m_R} = \frac{35.0\,N\,[W]}{15.0\,kg} = 2.33\ m/s^2\ [W]$$

$\vec{F}_{R\,on\,C} = 35.0\,N\,[E]$

$m_C = 21.0\ kg$

$\vec{a}_C = ?$

$$\vec{a}_C = \frac{\vec{F}_{R\,on\,C}}{m_C} = \frac{35.0\,N\,[E]}{21.0\,kg} = 1.67\ m/s^2\ [E]$$

c) If the force was applied for a time of 0.25 seconds, find the final velocity of each character at the end of the 0.25 seconds.

Roadrunner

$\Delta t = 0.25\,s$

$v_1 = 0$

$v_2 = ?$

$\vec{a} = 2.33\ m/s^2\ [W]$

$$v_2 = v_1 + a\Delta t$$

$$= 0 + (2.33\ m/s^2)(0.25\,s)$$

$$= 0.58\ m/s\ [W]$$

Coyote $\quad v_1 = 0,\ \vec{a} = 1.67\ m/s^2\ [E]$

$$v_2 = v_1 + a\Delta t$$

$$= (1.67\ m/s^2\ [E])(0.25\,s)$$

$$= 0.42\ m/s\ [E]$$

Extra dynamics Problem Answers:

1a) <u>Head rests in cars:</u> If a car at rest is hit in a rear-end collision, it will be accelerated forward. The seat will apply an unbalanced force on the body of a passenger inside the car causing their body to accelerate forward as well. However, due to its inertia, the head of the passenger will tend to stay at rest and will appear to "snap back" causing a whiplash injury. The head re will apply an unbalanced force on the head to accelerate it forward with the body, preventing whiplash injuries.

b) <u>Seat belts in cars:</u> When a car is in motion the passengers inside are moving along with the car. If the car comes to a sudden stop, a passenger inside will continue moving forward due to their inertia and may become injured by striking the dashboard, etc. A sealt belt applies an unbalanced force on the passenger's body to accelerate them to rest along with the car.

c) <u>Speed limits on curved ramps:</u> Due to its inertia, a car moving at a constant velocity would like to continue moving forward at a constant velocity. In order to turn or travel around a curve, there must be an unbalanced force acting on the car that comes from the force of friction of the road acting on the tires. If the surface of the road is slippery, the coefficient of static friction will be lowered so that the [illegible] sufficient frictional force to [illegible] →

car to make the turn. Lowering the initial speed of the car will lower the net force needed for the car to round the turn, so that the road should be able to ~~to~~ provide the required frictional force and the car will round the curve without skidding.