Name____

Physics 110 Quiz #4, April 28, 2023

Please show all work, thoughts and/or reasoning to receive partial credit. The quiz is worth 10 points total.

I affirm that I have carried out my academic endeavors with full academic honesty.

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To test the efficacy of brakes on stopping cars, auto manufacturers drive their cars of mass $1500kg$ ($\sim 3300lbs$) down a flat level road at a constant speed $27\frac{m}{s}$ ($\sim 60\frac{mi}{hr}$). At a predetermined point, they slam on the brakes and the car comes to rest over a distance Δx.

a. How much work was done by friction bringing the car to rest?

$$W = \Delta K = \frac{1}{2}mv_{fx}^2 - \frac{1}{2}mv_{ix}^2 = -\frac{1}{2}mv_{ix}^2 = -\frac{1}{2} \times 1500kg \times \left(27\frac{m}{s}\right)^2 = -5.5 \times 10^5 J$$

b. What was the coefficient of friction between the car and the road if the car comes to rest over a distance $\Delta x = 200m$?

$$W = F_{fr}\Delta x \cos\phi = \mu F_N \Delta x \cos\phi = \mu mg\Delta x \cos 180 = -\mu mg\Delta x$$

$$\mu = -\frac{W}{mg\Delta x} = -\left(\frac{-5.5 \times 10^5 J}{1500kg \times 9.8\frac{m}{s^2} \times 200m}\right) = 0.19$$

c. After all these trials testing brakes, the brakes will eventually wear out and need to be replaced. To replace the brakes, we need to lift the car up into the air a height $\Delta y = 2m$ to work on it. To do this, suppose you use a vertical lift and pick the car up vertically from rest and when it gets to height Δy it comes back to rest. How much work was done by the lift on the car?

$$W = F_W \Delta y \cos\phi = mg\Delta y \cos 0 = mg\Delta y = 1500kg \times 9.8\frac{m}{s^2} \times 2m = 2.9 \times 10^4 J$$

d. Suppose that your lift is broke, but you still need to get the car $\Delta y = 2m$ into the air to work on it. You decide to use a ramp inclined at an angle of $\theta = 20^0$ measured with respect to the ground. If the ramp is frictionless and you push the car up the ramp at a constant speed, how much work do you do to get the car to the top of the ramp a height $\Delta y = 2m$ above the ground?

Parallel to the ramp we have

$F_{you} - F_{wx} = ma_x = 0 \rightarrow F_{you} = F_{wx} = mg \sin\theta$

$W = F_{you}\Delta x \cos\phi = mg \sin\theta \left(\frac{\Delta y}{\sin\theta}\right) \cos 0 = mg\Delta y$

$W = 1500kg \times 9.8\frac{m}{s^2} \times 2m = 2.9 \times 10^4 J$

Where from the geometry,

$\sin\theta = \frac{\Delta y}{\Delta x} \rightarrow \Delta x = \frac{\Delta y}{\sin\theta}$

e. Comparing your answers to parts c and d, you should find that the work done in either case is the same. In this case, what is the point of using the ramp as opposed to simply "picking" the object up vertically?

The work done in either case is the same. In part c, the force you need to apply is greater (mg) compared to the force in part d ($mg \sin\theta$). However, in part d, you must apply the smaller force over a much larger distance $\frac{\Delta y}{\sin\theta}$ as opposed to simply Δyas in part c. The ramp allows you to use a smaller force, but not for free as the distance is larger.