Quiz #4

PHYSICS 1500

16 February, 2006

You are not allowed to use any outside sources of information during the quiz. Please use the attached sheet for scratch work and write only your final answer on this page. For quantitative problems don’t forget to write your answer with the correct number of significant figures and include units. Include diagrams when appropriate.

When you are finished, fold the quiz in half along the the length of the paper and write your name on the top right of the back side.

Problem #1  Jack and Jill decide to share water carrying duties on their way down from the hill. However, they have two different lengths of rope that are both tied to the water pail. As they walk the longer rope makes an angle of $35^\circ$ with respect to the horizontal, while the shorter rope makes an angle of $45^\circ$. The mass of the pail and its contents is $6.35\, \text{kg}$. What is the tension in each rope?

Answer: Dividing the forces into their $x$ and $y$ components gives us a system of two equations with two unknowns which is easily solvable. Let the two ropes be denoted by the subscripts L (for long) and S (for short).

\[ T_{Lx} = T_{Sx} \]  \hspace{1cm} (1)

\[ T_L \cos \theta_L = T_S \cos \theta_S \]  \hspace{1cm} (2)

\[ \Rightarrow T_L = T_S \frac{\cos \theta_S}{\cos \theta_L} \]  \hspace{1cm} (3)

\[ T_{Ly} + T_{Sy} = mg \]  \hspace{1cm} (4)

\[ mg = T_L \sin \theta_L + T_S \sin \theta_S \]  \hspace{1cm} (5)

\[ mg = T_S \frac{\cos \theta_S}{\cos \theta_L} \sin \theta_L + T_S \sin \theta_S \]  \hspace{1cm} (6)

\[ \Rightarrow T_S = \frac{mg}{\tan \theta_L \cos \theta_S + \sin \theta_S} = \frac{(6.35\, \text{kg})(9.80\, \text{m/s}^2)}{\tan 35^\circ \cos 45^\circ + \sin 45^\circ} \]  \hspace{1cm} (7)

\[ = 51.8 \, \text{N} \]  \hspace{1cm} (8)

\[ T_L = T_S \frac{\cos \theta_S}{\cos \theta_L} = 51.8 \, \text{N} \frac{\cos 45^\circ}{\cos 35^\circ} = 44.7 \, \text{N} \]  \hspace{1cm} (9)

Problem #2  A $5.25\, \text{kg}$ block is given an initial velocity of $4.20\, \text{ft/s}$ up an surface inclined at $40^\circ$. If the coefficient of friction between the block and the surface is $0.360$, how far (in meters) along the incline does the block slide before coming to rest?

Answer: With the $x$ coordinate chosen along the incline we can find the net force acting on the block along the plane and thus the acceleration of the block along the plane.

\[ -F_{gx} - F_f = ma_x \]  \hspace{1cm} (10)

\[ \Rightarrow a_x = -\frac{1}{m} [F_g \sin \theta + \mu F_g \cos \theta] \]  \hspace{1cm} (11)

\[ = -\frac{mg}{m} [\sin \theta + \mu \cos \theta] \]  \hspace{1cm} (12)

\[ = -9.80\, \text{m/s}^2 [\sin 40^\circ + 0.360 \cos 40^\circ] \]  \hspace{1cm} (13)

\[ = -9.00\, \text{m/s}^2 \]  \hspace{1cm} (14)

\[ v^2 - v_0^2 = 2a_x \Delta x \]  \hspace{1cm} (15)
\[ \Rightarrow \Delta x = \frac{v^2 - v_0^2}{2a} \quad (16) \]
\[ = 0 - \left[ \frac{(4.20 \text{ ft/s})(1 \text{ m/s} / 3.281 \text{ ft/s})}{2(-9.00 \text{ m/s}^2)} \right]^2 \quad (17) \]
\[ = 9.10 \times 10^{-2} \text{ m} \quad (18) \]

**Problem #3 (Extra Credit)** A classic parlor trick is the old removal-of-the-table-cloth-without-breaking-the-dishes. When done correctly the performer is able to pull a table cloth off of a table while leaving the plates, forks, glasses, etc. on top of the table. Using physics language (i.e. force, acceleration, mass, etc.) describe why this trick works. Draw a free body diagram for the table cloth and one for a representative plate on the table. Under what conditions will the plate not slide off the table?

**Answer:** The only external force that acts on the dishes in the direction parallel to the table is the force of friction between the tablecloth and the dishes. While this force can never be zero, it is certainly possible that the force of friction will not be large enough to accelerate the dishes very quickly. In this case, the dishes will accelerate for a small time while the tablecloth is pulled beneath them but they will come to rest again not far from where they started after the tablecloth has been removed (assuming the coefficient of friction between the dishes and the table is relatively large).