Name___________________________

Physics 120 Take-Home Quiz#1

Directions: You may use your notes or any text to answer these two questions. You may consult with me, but not your fellow classmates. Your responses must be written showing your complete thoughts in order to receive partial credit. ***This take-home quiz is due on Monday, January 22, 2007 by the end of class. Late quizzes will not be accepted.***

1. If you jump from a desktop and land stiff-legged on a concrete floor, you run a significant risk that you will break a leg. To see how that happens, consider the average force stopping your body when you drop from rest from a height of 1.00 m and stop in a much shorter distance *d*. Your leg is likely to break at the point where the cross-sectional area of the bone (the tibia) is smallest. This point is just above the ankle, where the cross-sectional area of one bone is about 1.60 cm^2.

   A bone will fracture when the compressive stress on it exceeds about 1.60×10^8 N/m^2. If you land on both legs, the maximum force that your ankles can safely exert on the rest of your body is then about $2 \times (1.60 \times 10^8 \text{ N/m}^2)\times(1.60 \times 10^{-4} \text{ m}^2)$ $= 5.12 \times 10^4$ N

   Calculate the minimum stopping distance *d* that will not result in a broken leg if your mass is 60.0 kg. Don't try it! Bend your knees!

$$v_{fx}^2 = v_{ix}^2 + 2a\Delta x = 2\times\left(-9.8\tfrac{m}{s^2}\right)\times\left(-1.0m\right) \rightarrow v_{fx} = -4.43\tfrac{m}{s}$$

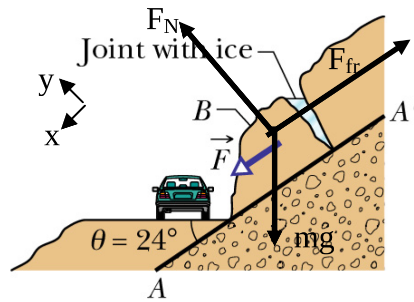
$$\text{In stopping}: \sum F_x = ma_x \rightarrow 5.12\times10^4 N - \left(60kg\times9.8\tfrac{m}{s^2}\right) = 60kg\times a$$

$$\therefore a = 844\tfrac{m}{s^2}$$

$$\min d : v_{fx}^2 = v_{ix}^2 + 2ad \rightarrow 0 = \left(-4.43\tfrac{m}{s}\right)^2 + 2\left(844\tfrac{m}{s^2}\right)\left(-d\right) \rightarrow d = 0.0116m = 1.16cm!!$$

2. The figure below shows the cross section of a road cut into the side of a mountain. The solid line **AA'** represents a weak bedding plane along which sliding is possible. Block B directly above the highway is separated from uphill rock by a large crack (called a *joint*) so that only friction between the block and the bedding plane prevents sliding. The mass of the block is 1.8×10^7 kg, and the *dip angle* θ of the bedding plane is 24^o, and the coefficient of static friction between the block and plane is 0.63.

    a. Show that the block will not slide.



From a free body diagram:

$$\sum F_y : F_N - mg\cos\theta = ma_y = 0$$

$$\sum F_x : -F_{fr,s} + mg\sin\theta = ma_x = 0$$

$$\therefore mg\sin\theta = F_{fr,s} = \mu_s F_N = \mu_s mg\cos\theta \rightarrow \mu_s = \tan\theta$$

maximum angle without slipping : $\theta = \tan^{-1}(\mu_s) = \tan^{-1}(0.63) = 32.2^0$.

Thus since we are only at $24^0 < 32.2^0$, the rock does not slide.

    b. Water seeps into the joint and expands upon freezing, exerting on the block a force **F** parallel to **AA'**. For what minimum value of **F** will a slide be triggered?

$$\sum F_y : F_N - mg\cos\theta = ma_y = 0$$

$$\sum F_x : -F_{fr,s} + mg\sin\theta + F_{\min} = ma_x = 0$$

$$\rightarrow F_{\min} = F_{fr,s} - mg\sin\theta = \mu_s mg\cos\theta - mg\sin\theta = mg(\mu_s\cos\theta - \sin\theta)$$

$$\therefore F_{\min} = 1.8\times10^7\,kg \times 9.8\tfrac{m}{s^2}(0.63\times\cos 24 - \sin 24) = 2.98\times10^7\,N$$