9×3 + 7×3 = 27 + 21 = 48

Students

Tear off Sheet

Physics 135a Midterm

Summer 2004
Wed. June 9th
10:00am–12:00noon

Name (printed): ______________________________
Last First Initial

This is a closed book exam. No notes or other materials are allowed. However calculators are permitted. Please express all numerical results with the appropriate number of significant figures.

The emphasis of this exam is on your method of problem solving: A correct answer with little, or no working will earn very few points. A wrong answer, but with a largely correct method will earn you a major portion of the points. Show and explain your working as much as possible.

Your signature represents that you understand these rules and that you agree neither to give nor receive help during this exam,

Name (signed): ______________________________

Social Security No.: ____________________

Physics 135a Midterm

Summer 2004
Wed. June 9th
10:00am–12:00noon

Name (printed): ______________________________
Last First Initial

Name (signed): ______________________________

1.__________

2.__________

3.__________

4.__________

5.__________

Total:__________

1. (20pts) Short Answer Questions

4 (a) Convert the energy of $1.00 hp \cdot h$ (horsepower hour) into J (Joule).

$1.00\, hp \cdot h = 550 \frac{ft\, lb}{s} \cdot 3600 s = 550 \cdot \frac{m}{3.281} \cdot 4.448 N \cdot 3600$

$= 2.68 \cdot 10^6 J$

4 (b) The distance from earth to sun is about 8 light minutes. How much is this in miles?

$8 \cdot 60 s \cdot 3 \cdot 10^8 \frac{m}{s} = 1.44 \cdot 10^{11} m = 1.44 \cdot 10^{11} \cdot 0.621 \cdot 10^{-3} mi$

$= 9 \cdot 10^7 mi$

4 (c) Estimate the number of grains of sand in $1 ft^3$ of sand.

$\frac{1 ft^3}{(0.5 \cdot 10^{-3} m)^3} = \frac{1}{(3.281)^3 \cdot (0.5 \cdot 10^{-3})^3} = 2 \cdot 10^8$ grains. $\simeq 10^8$

4 (d) Estimate the diameter d that a stadium would have to have in order to accomodate the world population (6 billion people) for a rock concert (the area of a circle is $A = \frac{\pi}{4} d^2$). How does that compare to the size of greater Los Angeles?

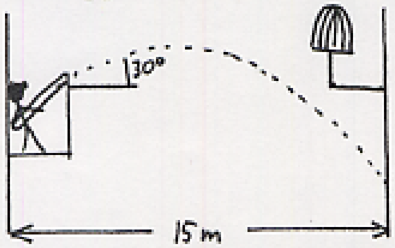
$A = \frac{\pi}{4} d^2 \rightarrow d = \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{4 \cdot 6 \cdot 10^9 m^2}{\pi}} = 9 \cdot 10^4 m = 90 km$

Similar size as Greater LA!

1 (e) In an action movie there is a car chase where a motorcycle is riding on top of a truck. The truck is driving at $82 \frac{mi}{h}$ on a highway and motorcycle is moving at $37 \frac{mi}{h}$ with respect to the roof of the truck in the opposite direction to the truck. What velocity (in $\frac{m}{s}$) does the motorcycle have with respect to a bridge across the highway?

$v = 82 \frac{mi}{h} - 37 \frac{mi}{h} = 45 \frac{mi}{h} = 45 \frac{1000 m}{0.621 \cdot 3600 s} = 20 \frac{m}{s}$

2. (20pts) In his latest scheme to catch Tweety, Sylvester has set up a catapult on the balcony of a house. His goal is to reach Tweety located in a cage on the balcony of the house on the opposite side of the street. Sylvester launches himself upwards at an angle of 30° to the horizontal at a speed of $10\frac{m}{s}$. Sadly this is an insufficient speed, and Sylvester slams into the wall of Tweety's house. Suppose that the street is $15m$ across.



5 (a) What height does Sylvester reach above his launch point?

$v_{f/y}^2 = v_{i/y}^2 - 2g\,\Delta y$

$\rightarrow \Delta y = \frac{v_{i/y}^2}{2g} = \frac{(10\frac{m}{s} \cdot \sin 30°)^2}{2 \cdot 9.8\frac{m}{s^2}} = \underline{\underline{1.3m}}$

5 (b) What is his time of flight before impact?

$x = v_x \cdot t$

$\rightarrow t = \left(\frac{v_x}{x}\right)^{-1} = \left(\frac{10\frac{m}{s} \cdot \cos 30°}{15\,m}\right)^{-1} = \underline{\underline{1.7\,s}}$

5 (c) Where does he hit the wall (relative to his launch point)?

$y = v_{0y} \cdot t - \frac{1}{2}g t^2 = \underline{\underline{-6.0\,m}}.$

5 (d) What is his speed and direction of motion on impact?

$v_x = 10\frac{m}{s} \cdot \cos 30° = 8.66\,\frac{m}{s}$

$v_y = v_{0/y} - g\,t = -12.0\,\frac{m}{s}$

$\rightarrow v = \underline{\underline{15\,\frac{m}{s}}}$

$\tan\theta = \frac{v_y}{v_x} \;\; \theta = -54°$

3. (20pts) Another scheme to catch the roadrunner has failed. A 100kg safe falls from rest from top of a 25m high cliff toward Wile E. Coyote, who is standing at the base.

5 (a) Wile E. Coyote is 1.5m tall. With what velocity does the safe hit his head?

$v_f^2 = v_i^2 - 2g\,\Delta y$

$v_f^2 = -2 \cdot 9.8 \frac{m}{s^2} \cdot (-23.5\,m)$

$v_f = \underline{21 \frac{m}{s}}$

5 (b) When the safe comes to rest, Wile E. Coyote is compressed to 10cm. What work is done on him during this crash? (Hint: Use the work-energy theorem!)

$E_i = mgy_i$, $E_f = mgy_f$ $\Rightarrow$ $\Delta E = mg(y_f - y_i) = -2.4 \cdot 10^4\,J$

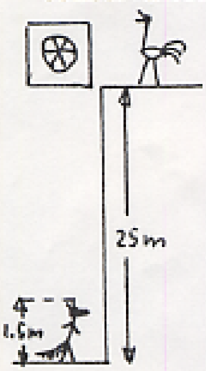
$W_{\text{done by } C} = -2.4 \cdot 10^4\,J$

$W_{\text{done on } C} = \underline{2.4 \cdot 10^4\,J}$

5 (c) What is the average force exerted on Wile E. Coyote during this crash?

$\bar{F} = \frac{W}{\Delta y} = \frac{2.4 \cdot 10^4\,J}{1.4\,m} = \underline{1.7 \cdot 10^4\,N}$

5 (d) If we assume that Wile E. Coyote is a cartoon character and can be approximated by a spring, determine his spring constant. (Hint: Use conservation of energy!)



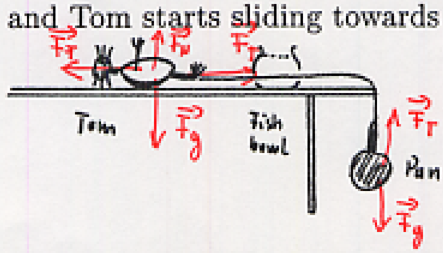
$E_i = mgy_i$

$E_f = mgy_f + \frac{1}{2}k\,\Delta y^2$

$\rightarrow \frac{1}{2}k\,\Delta y^2 = mg(y_i - y_f)$

$\rightarrow k = \frac{2mg(y_i - y_f)}{\Delta y^2} = \underline{2.5 \cdot 10^4 \frac{N}{m}}$.

4. (20pts) Tom, the cat, is sleeping peacefully on the top of the kitchen table when Jerry, the mouse, connects him with a fully streched string to a $5.1kg$ pan on the edge of the table. Tom is a $4.5kg$ cat and has a coeffitient $\mu_k = 0.30$ of kinetic friction with the table top. Jerry pushes the pan off the kitchen table and Tom starts sliding towards the edge.



4 (a) Draw all the forces acting on Tom and on the pan on the diagram.

(b) What is Tom's acceleration?

6

$F_N - mg = 0 \rightarrow F_N = mg$

$m_1 a = F_T - \mu_k \cdot m_1 g$

$-m_2 a = F_T - m_2 g$

$\rightarrow (m_1 + m_2) a = g(m_2 - \mu_k m_1)$

$\rightarrow a = \frac{m_2 - \mu_k m_1}{m_1 + m_2} g = 3.8 \frac{m}{s^2}$

5 (c) After $0.80s$ the pan hits the kitchen floor. What is Tom's velocity and momentum at this point? (If you couldn't solve problem (b), assume that Tom's acceleration is $5.0\frac{m}{s^2}$)

$v_T = a \cdot t = 3.1 \frac{m}{s}$

$p_T = 14 \frac{kg\,m}{s}$

Alt:

$v_T = a \cdot t = 4.0 \frac{m}{s}$

$p_T = 18 \frac{kg\,m}{s}$

5 (d) At the same time that the pan hits the kitchen floor, Tom hits a $7.2kg$ goldfish bowl. He holds on to the bowl. What is the velocity of Tom and the bowl after the perfectly inelastic collision?

$p_i = 14 \frac{kg\,m}{s}$

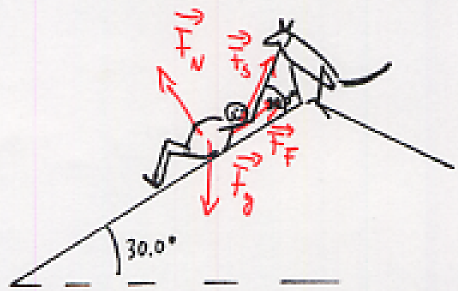
$p_f = (4.5kg + 7.2kg) v_f$

$\rightarrow v_f = 1.2 \frac{m}{s}$.

Alt:

$v_f = 1.5 \frac{m}{s}$

5. (20pts) Homer Simpson (95.0kg) is lying on the roof of his house about to slip off. The roof is inclined at an angle of 30.0° to the horizontal. The coefficient of static friction between Homer and the roof is $\mu_s = 0.450$. In order not to slip off the roof, he is holding on to the leash of Santa's Little Helper (SLH, Bart's dog) who is sitting on the top of the roof. The angle between the leash and the roof is 30.0° (see sketch).



5 (a) Draw all the forces acting on Homer into the diagram.

5 (b) Write the x- and the y-component of Newton's first law.

x: $-mg \sin 30.0° + F_s \cdot \cos 30.0° + \mu_s \cdot F_N = 0$

y: $F_N + F_s \cdot \sin 30.0° - mg \cos 30.0° = 0$

5 (c) What is the magnitude of the force with which SLH has to pull on the leash in order that Homer doesn't fall? (Hint: Use the coordinate system indicated in the diagram.)

$$-mg \sin 30.0° + F_s \cos 30.0° + \mu_s mg \cos 30.0° - \mu_s F_s \cdot \sin 30.0° = 0$$

$$\rightarrow F_s = \frac{\sin 30.0° - \mu_s \cos 30.0°}{\cos 30.0° - \mu_s \sin 30.0°} mg = \underline{160\ N}$$

5 (d) SLH can pull with a maximal force of 163N on the leash. How many 80.0g doughnuts can Homer carry on the roof without slipping off?

$$m = \frac{F_s}{g} \frac{\cos 30.0° - \mu_s \sin 30.0°}{\sin 30.0° - \mu_s \cos 30.0°} = 96.7\ kg$$

$$m_D = 96.7\ kg - 95.0\ kg = 1.7\ kg$$

$$\frac{1.7\ kg}{0.0800\ kg} = 20.9 \rightarrow \underline{20\ \text{doughnuts}!}$$