Test 2 - Review
PH 241N

Dr. Weppner
Nov. 2006

NAME ______________ ☐ Pledged SCORE____ / 100 pts

Remember to get full credit label answers with correct units, show all work, draw diagrams, give axis directions, write all applicable formuli.

1. [10 pts] What is the minimum work needed to push a 950 kg car up a 310 meter high hill sloped at 9.0 degrees. Ignore Friction.

Work overcome gravity mgh

$(950 kg)(9.8 m/s^2)(310 m) =$

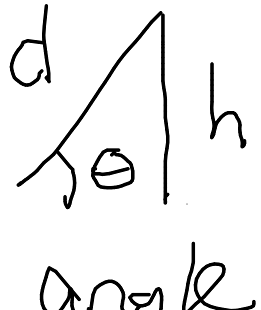
2.9×10^6 J

2. [10 pts] A hill has a height h. A child on a sled (total mass m) slides down starting from rest at the top. Does the velocity at the bottom depend on the angle of the hill if
(a) there is no friction
(b) there is friction

a) Energy does not depend on angle
Energy is conserved with no friction

b) $\Delta E = W_f = \mu_K F_N d$

$F_N = mg\cos\theta$



$d = h/\sin\theta$

So yes angle dependence

3.[**5 pts**] A woman runs up a flight of stairs. The gain in her potential energy is U. If she ~~ran up~~ the same stairs with twice the speed, what will be her gain in potential energy?

[✓ (a) U]
(b) 2U
(c) U/2
(d) 4U
(e) U/4

Same - mgh

4. [10 pts] It used to be common wisdom to build cars to be as rigid as possible to withstand collisions. Today, though, cars are designed to have "crumple zones" that collapse upon impact (as opposed to rigidly bouncing off each other). What advantages does this have?

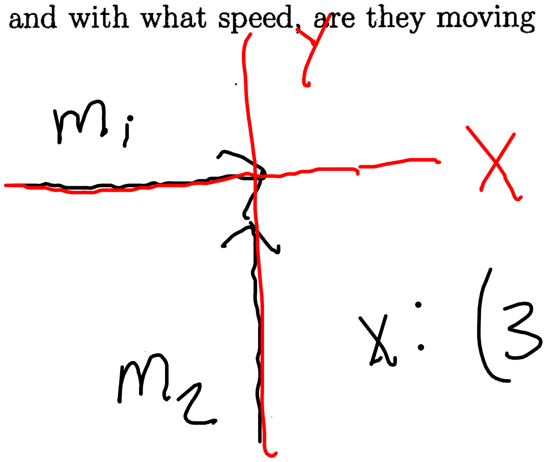
Impulse is less → $\Delta p = I = \bar{F}\Delta t$

so $\vec{F}$ is less

also Δt is longer.

Collision is inelastic, most of the energy is dissipated in the crumpling

7. [**18 pts**] An eagle ($m_1 = 3.3kg$) moving with speed $v_1 = 7.8m/s$ is on a collision course with a second eagle ($m_2 = 4.6kg$) moving at $v_2 = 10.2m/s$ in a direction **at right angles** to the first. After they collide they hold one to one another. In what direction, and with what speed, are they moving after the collision?



momentum conserved only

$$x: (3.3\,Kg)(7.8\,m/s) = (3.3Kg + 4.6Kg)V_x'$$

$$y: (4.6\,Kg)(10.2\,m/s) = (3.3Kg + 4.6Kg)V_y'$$

$$V_x' = 3.26\,m/s$$

$$V_y' = 5.94\,m/s$$

$$V' = \sqrt{(3.26\,m/s)^2 + (5.94\,m/s)^2} = 6.78\,m/s$$

$$\theta = \tan^{-1}\left(\frac{5.94\,m/s}{3.26\,m/s}\right)$$

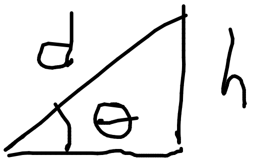
$$= 61^\circ$$

8. **[22 pts]** In 1987, British skier Graham Wilkie achieved a speed of 58.6 m/s (131 mph!) going downhill. Assuming that he reached a maximum speed at the end of the hill and then continued on the horizontal surface, find the maximum distance he could have covered on the horizontal surface. Take the coefficient of kinetic friction μ_k to be constant throughout the run; neglect air resistance. Assume the hill is 225 m high with a constant slope of 30^o with the horizontal (Hint: $F_N = mg\cos\theta$ while on the hill).

$$\Delta E = \cancel{E_{pokes}} + E_{friction} \quad (\text{External})$$

$$= \mu_K F_N d = -\mu_K mg \cos 30^\circ d$$

$$d = \frac{h}{\sin 30^\circ}$$



$$\text{so } \Delta E = -\mu_K mg \frac{\cos 30^\circ h}{\sin 30^\circ}$$

$$\Delta E = \tfrac{1}{2}mv^2 - mgh = E_f - E_o \quad (\text{going downhill})$$

$$\tfrac{1}{2}\cancel{m}v^2 - \cancel{m}gh = -\mu_K \cancel{m}g \frac{\cos 30^\circ}{\sin 30^\circ} h$$

$$\tfrac{1}{2}(58.6\,m/s)^2 - (9.8\,m/s^2)(225\,m) = -\mu_K g(1.73)(225\,m)$$

$$\mu_K = .13$$

on horizontal surface $\Delta E = -\tfrac{1}{2}\cancel{m}(58.6)^2 = -.13\cancel{m}gd'$

$$d' = 1.35 \times 10^3\ m$$

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1. [8 pts] A lump of soft clay of mass m falls from a height h above the floor (initially at rest), where it crashes and comes again to rest.
(A) How much work is done by the floor on the clay?
(B) How much work does gravity do on the clay?
(C) What is the total work done on the clay during the fall and collision?

$W_{TOT} = \Delta K = 0$ $W_g = mgh$

$W_g + W_{floor} = 0$ $W_f = -mgh$

2. [6 pts] Show that the amount of force that a human imparts on an airbag during a car accident would be less than the force the human would impart if the airbag were missing.

Δp is same in both cases.

$V_0 = \text{same}$ $V_f = 0$

$\Delta p = I = \bar{F}\Delta t$ so $\bar{F} = \dfrac{\Delta p}{\Delta t}$

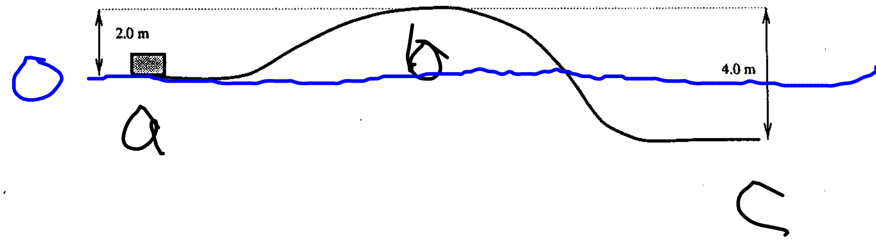
Δt longer for airbag so $\vec{F}$ is less

3. [4 pts] Two carts with different masses are at rest on a horizontal track. A person pushes each cart for 2 seconds. ignoring friction and assuming an equal force was exerted on both cars, the momentum of the light cart after the push is
(A) smaller than the heavier car
[✓ (B) the same as the heavier car]
(C) larger than the heavier car
(D) The answer depends on the masses of the two carts

$\Delta p = \bar{F}\Delta t$

Δt and $\bar{F}$ are same

4. [10 pts] Referring to the figure, if the speed of the block is 4.0 m/s before the hill, what would be the speed of the block after the hill?



$E_a = E_b = E_c$

$E_a = \frac{1}{2}m(4m/s)^2$

$E_b = mg(2m) + \frac{1}{2}mV_b^2$

$V_b^2 < 0$ cannot clear hill

5. [6 pts] A firecracker explodes in midair. Considering all the fragments in mid-air right after the explosion compared to right before the explosion,

(A) the total KE remains constant
(B) the total momentum decreases
(C) the total KE decreases
[✓ (D) the total momentum remains constant]
(E) none of these
Explain your answer.

Explosion is internal
Disspates
Energy

6. [8 pts] You are using a wrench and trying to loosen a rusty nut. Which of the arrangements shown is most effective in loosening the nut? List in order of descending efficiency.

9. [14 pts] A railroad freight car of mass 31800 kg collides with a stationary caboose car. They stick together and 27% of the initial kinetic energy is lost to thermal energy, sound, vibrations, and so on. Find the mass of the caboose.

① $m_{fc} V_o = (m_{fc} + m_c) V_f$ momentum

② $\frac{1}{2} m_{fc} V_o^2 (.73) = \frac{1}{2} (m_{fc} + m_c) V_f^2$ Energy

① squared $\Rightarrow m_{fc}^2 V_o^2 = (m_{fc} + m_c)^2 V_f^2$

$\frac{①}{②} \Rightarrow \frac{m_{fc}}{.73} = (m_{fc} + m_c) \Rightarrow m_c = m_{fc}\left(1 + \frac{1}{.73}\right)$

$= 75400$ Kg

~~10. [14 pts] A track is mounted on a large wheel that is free to turn with negligable friction about a vertical axis (see figure below). A toy train of mass m is placed on a track and, with the system initially at rest, the electrical power is turned on. The train reaches a steady speed of v with respect to the track. What is the angular speed of the wheel if its mass M and its radius R? Treat the wheel as a hoop with $I = MR^2$.~~