Physics 200

Name KEY

Exam 2 – Energy and Momentum

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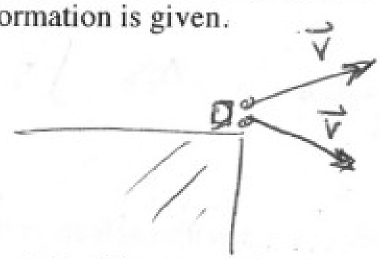
October 22, 2008

This is a closed book examination; however, you may use an index card during the exam. There is extra scratch paper available. Your explanation is worth ¾ of the points. Explain your answers!

A general reminder about problem solving:

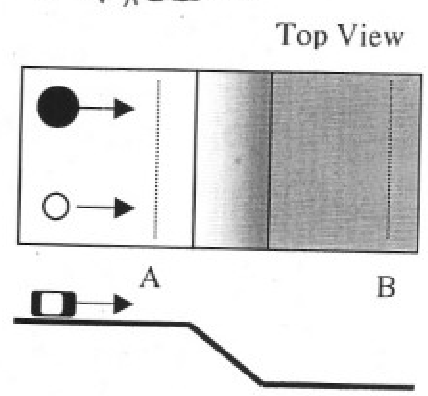
1. Draw a picture then create a simplified free body diagram with all forces
2. Write down what you know including coordinate frame
3. Write down what you don't know and/or want to know
4. List mathematical relationships
5. Simplify and solve
6. Check your answer – Is it reasonable? Are units correct?
- Show all work! (Use extra paper if needed.)

1. [4 PTS] Two identical objects are thrown from a building with the same velocity but at different angles (one above the horizontal and the other below the horizontal). Which statement is true?
   A. Both balls hit the ground at the same time but with different speeds.
   B. Both balls hit the ground at the same time and with the same speed.
   C. Both balls hit the ground at different times but with the same speed.
   D. Both balls hit the ground at different times and with different speeds.
   E. Not enough information is given.



E_i is same for both so speeds ($|\vec{v}|$) will be same but trajectories are different so time is different

The next six questions refer to the diagram to the right and involve two disks. The disks, both initially at rest, are pushed with the same force for the same amount of time along a level surface. The push stops before either disk reaches line A. The black disk has twice the mass of the white disk. After the disks are pushed they travel down an incline and then back to a level surface. Assume that the surfaces are frictionless.



2. [4 PTS] Which disk has gained more energy when it crosses line A?
   A. The white disk.
   B. The black disk.
   C. Both disks gained the same energy.
   D. Not enough information.

$V_i = 0$

$$\int F \cdot dt = \Delta p \qquad \Delta E = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = \frac{1}{2}\frac{p_f^2}{m}$$

$p_f = F\Delta t$

$$\Delta E = \frac{(F\Delta t)^2}{2m}$$

light disk has more energy

3. [4 PTS] Which disk has a greater change in momentum ($|\vec{p}|$) when it crosses line A?
   A. The white disk.
   B. The black disk.
   C. Both disks have the same change in momentum.
   D. Not enough information.

$\int F \cdot dt = \Delta p$ so both have the same

4. [4 PTS] Which disk is traveling at a greater velocity when it crosses line A?
   A. The white disk.
   B. The black disk.
   C. Both disks have the same velocity.
   D. Not enough information.

$p_A = p_B$ $\quad m_A v_A = m_B v_B$ so light disk is travelling faster

5. [4 PTS] Which disk has a greater change in momentum ($|\vec{p}|$) when it travels from the start and crosses line B?
   A. The white disk.
   B. The black disk.
   C. Both disks have the same change in momentum.
   D. Not enough information.

$F = mg\sin\theta$

angle of incline

Down incline

$F_B > F_w$ and Δt is same (fall times are the same)

$\Delta p_B = \int F_B \cdot dt > \Delta p_w = \int F_w \cdot dt$

6. [4 PTS] Which disk is traveling at a greater velocity when it travels from the start and crosses line B?
   A. The white disk.
   B. The black disk.
   C. Both disks have the same velocity.
   D. Not enough information.

When object goes ~~...~~ down incline

$PE_i + KE_i = PE_f + KE_f$

$\cancel{m}gh = \frac{1}{2}\cancel{m}(v_f^2 - v_i^2)$

change in velocity is mass indep

$v_f = (2gh + v_i^2)^{1/2}$

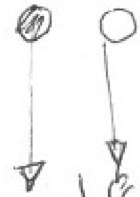
7. [4 PTS] Which disk has gained more kinetic energy when travelling from line A to line B?
   A. The white disk.
   B. The black disk.
   C. Both disks gained the same energy.
   D. Not enough information.

$PE_G = mgh$

h is the same but $m_B > m_w$

So ~~PE~~ $\Delta KE_B > \Delta KE_W$

8. [4 PTS] A massive ball and a light ball of the same radius are dropped from the roof of a building. Ignore air drag.
   A. Both balls hit the ground at the same time but with different velocities.
   B. Both balls hit the ground at the same time and with the same energy.
   C. Both balls hit the ground at different times but with the same velocity.
   D. Both balls hit the ground at different times but with the same energy.
   E. None of the above.



No drag

ΔE is different
$PE_G = mgh$
Δt is same
Δv is same

9. [4 PTS] A bouncy ball and a clay ball of identical mass are thrown at a wall with the same velocities. Which ball exerts a greater force on the wall?
   A. The clay ball.
   B. The bouncy ball.
   C. Both balls exert the same force.
   D. Not enough information is given.

$\int F \cdot dt = \Delta p$
Bouncy $\Delta p_B > \Delta p_C$ Clay
Assume Δt is same then
$F_B > F_C$

10. [4 PTS] Can a particle that has a constant kinetic energy be accelerating?
   A. Yes.
   B. No.
   C. Depends on the mass.

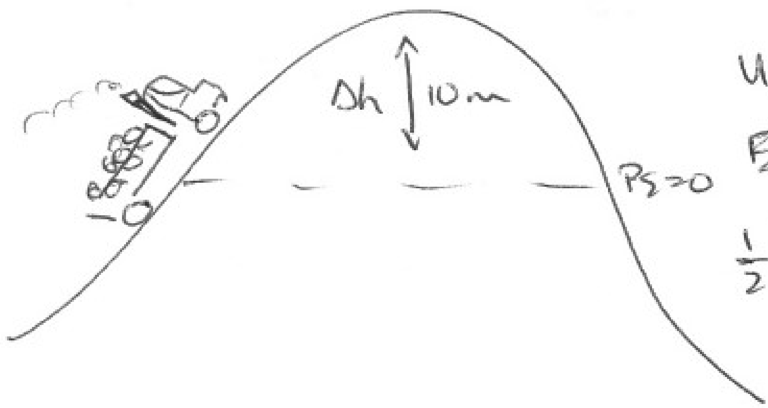
Yes – a particle traveling is circular motion
$\frac{1}{2}mv^2$ is constant but $a_c = \frac{v^2}{r}$

Please solve the next two problems using additional paper or some problem solving sheets.

11. [10 PTS] A truck carrying a load of sugar beets is halfway up a 20 m tall hill when it runs out of gas (stopping the engine). If the truck is traveling at 13.5 m/s (and there are no frictional losses) will it make it over the top of the hill? Would it help to throw out some beets (or a cat) to reduce the mass?

12. [20 PTS] A 15 kg object, initially at rest, is pushed horizontally with a constant force of 162 N for 2 meters on a thick carpet ($\mu_k = 0.9$).
   A. What is the change in kinetic energy?
   B. What is the change in momentum?
   C. How long is the object pushed?
   D. Does the object's final speed depend on what angle you push it?

$\boxed{11}$



Use conservation of energy

$E_i = E_f$

$\frac{1}{2}mv_i^2 \geq 0 + mg\Delta h$

find Δh

$\Delta h \leq \frac{v_i^2}{2g} = 9.3\,m$

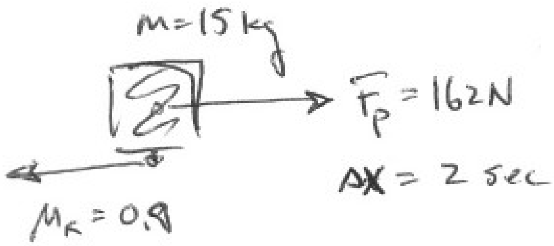
$v_i = 13.5\,m/s$

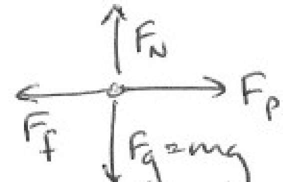
(A) $h \approx 9.3\,m$ so truck does not make it over the hill —

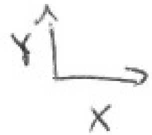
(B) Reducing mass will not help since the energy conservation is mass independant —

Note If you threw the beets down the hill the impulse (Δp) could help...

$\boxed{12}$







$\sum \vec{F} = m\vec{a}$

Y: $F_N = mg$ since $a_y = 0$ $\quad F_f = \mu F_N = \mu \cdot mg$

X: $F_p - \mu mg = ma_x$ $\quad a_x = \frac{F_p - \mu_k mg}{m}$

$$a_x = \frac{162N - (0.9)(15kg)(9.8\,m/s^2)}{15kg} = 1.98\,m/s^2$$

continued

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(a) $W = \Delta KE$ $\qquad W = \int \vec{F} \cdot d\vec{x}$ $\qquad F_{NET} = F_p - \mu mg$

$$F_{NET} = 162N - (0.9)(15kg)(9.8 m/s) = 29.7 N$$

$$W = 29.7N \cdot 2m = \boxed{59.4 J = \Delta KE}$$

$KE = \frac{1}{2}mv^2$

(b) $V_i = 0 m/s$ so $V_f = \left[\frac{2(KE)}{m}\right]^{1/2} = 2.8 m/s$

$p_i = 0 \cdot kgm/s$

$p_f = (2.8 m/s)(15kg) = 42 kgm/s$ $\qquad \boxed{\Delta p = 42 \frac{kgm}{s}}$

(c) $\Delta x = \frac{1}{2}a_x t^2 + v_{ix} t$ $\qquad v_{ix} = 0$, $a_x = 1.98 m/s^2$, $\Delta x = 2m$ $\qquad V_{fx} = V_{ix} + a_x t$

$\left(\frac{2\Delta x}{a_x}\right)^{1/2} = t$ $\qquad t = \frac{V_{fx}}{a_x} = \frac{2.8 m/s}{1.98 m/s^2}$

$t = \left(\frac{2 \cdot (2m)}{(1.98 m/s)}\right)^{1/2} = \underline{1.42 \text{ sec}}$ $\qquad \underline{t = 1.41 \text{ sec}}$

☑ check of answer

(d) Yes

F_{NET} depends on the normal force and component of F_p

Pushing down: F_N increases so F_f increases and F_p decreases

$\therefore$ F_{NET} decreases

Pushing up: F_N decreases so F_f decreases and F_p decreases

$\therefore$ F_{NET} could be greater or less than a horizontal push