Physics 160 Name ________________

Lab Time ________________

Exam 3 – Energy and Momentum

November 10, 2010

- This is a closed book examination.
- You may use a 3x5 index card that you have made with any information on it that you would like. You must have your name, lab section and the date on your index card.
- There is extra scratch paper available.
- Please fill out the Scantron sheet completely
  - Include your test code.
  - Include your Dragon ID
  - Include your name
- Mark your exam and include explanations where needed. This will help you learn from your exam as well as provide any verification of your scantron sheet.
- Please make sure to fill out each "Problem Solving Sheet" completely
  - Include your test code
  - Include your Dragon ID
  - Include your name
  - Include your lab time
- Your explanation/work for the worked problems is worth ¾ of the points. You must use a separate "Problem Solving Sheet" for each problem.

A general reminder about problem solving:

1. Visualize - draw a picture
2. Pick a coordinate frame
3. Create a simplified picture – schematic with vectors describing motion
   a. 2D Motion: separate vectors into components
   b. Force Problem: create a simplified free body diagram
   c. Energy Problem: create energy level diagram(s)
4. Write down what you know – create separate columns for different directions
5. Write down what you don't know and/or what you want to know
6. List mathematical relationships
7. Combine mathematical formulas, Simplify and Solve
8. Check your answer – Is it reasonable? Are the units correct?

a) Show all work!

The next question concerns the collision of two balls drawn schematically to the right. Initially, the first ball is moving and the second ball is stationary. The collision is head-on for the first three questions; that is, the balls do not bounce at an angle.

1. Assume the collision is elastic and that ball 2 is much more massive than ball 1. After the collision
   a) ball 1 moves to the left
   b) ball 1 stops
   c) ball 1 continues to move to the right

> Ball 1 will have to move back to the left to conserve momentum

2. 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.

> The balls hit the ground with the same energy (hence same speed). The ball thrown down takes less time to reach the ground

3. Two solid disks are released to roll down an incline at the same time. Both disks have the same mass but one has a diameter twice the other. Which disk reaches the bottom of the ramp first? Assume both disks roll without slipping. Show your answer is correct by solving the physics for each situation
   a) The smaller disk
   b) The larger disk
   c) They reach the bottom at the same time

> The shape of the objects is the same. The mass drops out of the equation (try it) so they reach the bottom at the same time.

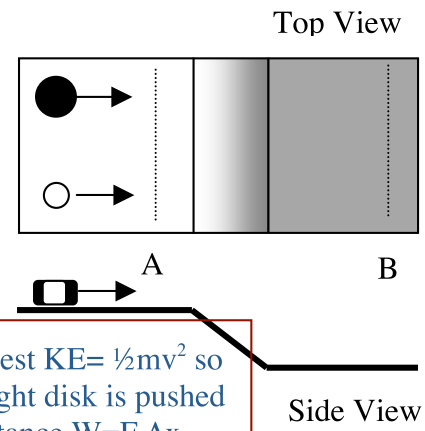
4. Given a solid disk and a ring that are the same diameter, can they have the same moment of inertia?
   a) Yes
   b) No

> In both cases the object's moment of inertia depends on the radius and mass. So change the mass till the moment of inertia is the same.

5. Given a disk and a solid sphere that are the same mass, can they have the same moment of inertia?
   a) Yes
   b) No

> Again adjust the radius till they have the same moment of inertia.

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.



6. 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.

#6 is 3rd easiest $KE=\frac{1}{2}mv^2$ so A; Alt the light disk is pushed a further distance $W=F\,\Delta x = \Delta E$ or $KE=p^2/(2m)$

7. 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.

#7 is easiest – so do it first. $F\Delta t=\Delta p$ is the same so C

8. 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.

#8 is 2nd easiest $p=mv$ so light ball is faster A

9. 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.

This is hardest… $F\Delta t=\Delta p$, same time to slide down (since they have same acceleration!) but forces different, so B Alt: use $p=(2mKE)^{1/2}$

10. 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.

Both disks have same change in velocity sliding down ramp (same acceleration!) so white was fastest and is still fastest, so A

11. 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.

Heavy puck has more PE at top of slide… it gains more KE since energy is conserved, so B
Alt: $W=F\,\Delta x = \Delta E$ same distance but different forces

Do the next two problems using separate problem solving sheets. There are extra problems solving sheets available if you need one.

12. You have volunteered to participate in a "Fun with Physics" Show. Your task is to design a circus stunt in which your physics professor, who weighs 160 pounds, is shot out of a cannon that is elevated 40^0 from the horizontal. The "cannon" is actually a 3-foot diameter tube that uses a stiff spring and a puff of smoke rather than an explosive to launch the professor. The manual for the cannon states that the spring constant is 1822 Newtons/meter. The spring is compressed by a motor until its free end is level with the bottom of the cannon tube, which is 5 feet above the ground. A small seat is attached to the free end of the spring for the professor to sit on. When the spring is released, it extends 9 feet up the tube (so the spring was compressed 9 feet when it started). Neither the seat not the chair touch the sides of the 12-foot long tube. After a drum roll, the spring is released and the professor will fly through the air with the appropriate sound effects and smoke. You have an airbag 3-feet thick for the professor to land on. You know that the airbag will exert an average retarding force of 3200 Newtons in all directions. You need to determine if the airbag is thick enough to stop the professor safely. -- that is, so he is slowed to a stop by the time he reaches ground level. To be safe, you assume the professor moves straight down after hitting the pad.

W=ΔE
professor
is dead…

13. You have been asked to determine the velocity of a car at an accident scene on Interstate 94 just across the ND/MN border. The car, a blue late model car with copious quantities of rust, is sitting on the side of the road where it came to a rest after skidding 37 meters. You can clearly see the rubber left on the road from the skidding tires. After consulting the car's manual you note that this model does not have power steering or antilock brakes and has an unloaded mass of 1000 kg. The trunk is open and empty but there are 150 kg of barbells sitting on the side of the road (the police think the driver dumped them after stopping). You assume the driver, a very nervous looking college student, slammed on the brakes the whole time. You consult your physics book and find that the value of the coefficients of friction for rubber tires and a dry concrete road are m_k=0.80 (kinetic) and m_s=0.98 (static). Assuming a constant acceleration determine the initial velocity of the car. Justify and explain all assumptions.

14. A triangular impulse (force vs time) is applied to a 10 kg object. The net force starts at 0N and rises to 50 N in 5 seconds at which time it decreases to 0N in 10 seconds. Assume the changing force is a linear function. What is the velocity of the object after the impulse has been applied?

Use FΔt=Δp (the area under the F(t) curve which is a triangle) then use p=mv