Physics 200 Name KEY

Lab Time (circle one): 9:00am 12:00pm 3:00pm

Exam 2 – Energy

October 25, 2012

This is a closed book examination. You may use a both sides of a 3"x5" notecard (or one side of a 4"x6" notecard) with equations, concepts or other soothing sonnets. 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!

1. [4 PTS] A 2.5 kg object on the asteroid *10 Hygiea* has an escape velocity of 160 m/s when launched from an equatorial location. What is the escape velocity for a 5.0 kg object launched from the same location?
   a) 40 m/s
   b) 80 m/s
   c) 160 m/s
   d) 320 m/s
   e) 640 m/s

The escape velocity does not depend on the mass of the object. The energy required does depend on the mass.

$v_{esc} = \sqrt{\frac{2GM}{R}}$ where M is mass and R is radius of asteroid.

2. [6 PTS] A planet is in a circular orbit around a star. Indicate which of the following statements about this circular orbit are **T**rue and which are **F**alse. Explain
   a) T At every instant $\frac{d\vec{p}}{dt}$ points from the planet to the star.
   b) T At any instant the momentum of the planet is tangent to the planet's trajectory.
   c) T The kinetic energy of the planet does not change.
   d) F The planet's momentum is constant.
   e) T The gravitational force on the planet due to the star always acts at a right angle to the planet's momentum.
   f) F The gravitational potential energy of the planet changes.

The magnitude of the momentum is constant but the direction changes. Energy is constant and gravitational force changes the direction of the momentum.

3. [4 PTS] A car makes a turn with a radius of 215 m while moving with a constant speed of 32.5 m/s. What is the magnitude of the acceleration of the car?
   a) 0.151 m/s^2
   b) 4.91 m/s^2
   c) 6.62 m/s^2
   d) 9.81 m/s^2
   e) 1422 m/s^2

The centripetal acceleration is $a = \frac{v^2}{r}$

4. [4 PTS] A spring is compressed 8 cm storing 20 J of energy. You compress the spring another 8 cm (for a total compression of 16 cm). What is the total energy stored in the spring?
   a) 10 J
   b) 20 J
   c) 40 J
   d) 80 J
   e) 160 J

Since $PE_{spring} = \frac{1}{2}kx^2$ if you double the compression you quadruple the energy stored. and you are removing twice the heat then the temperature

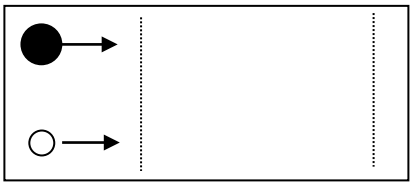
5. [4 PTS] An object is moving with constant magnitude momentum. What is the net force on this object? Explain.
   a) If $|\vec{p}| = constant$ then $\vec{F}_{net} = 0$
   b) If $|\vec{p}| = constant$ then $\vec{F}_{net} \neq 0$ ($\vec{F}_{net}$ is never zero)
   c) If $|\vec{p}| = constant$ then $\vec{F}_{net} \geq 0$ ($\vec{F}_{net}$ might be zero but it does not have to be zero)

An object moving in a circle has constant magnitude momentum but a net force is needed to change the direction of the momentum.

6. [4 PTS] A mass of water in an insulated cup, initially at $T = 40$ °C, has 100 J of heat added resulting in a change in temperature, $\Delta T = 10$ °C. What is the final temperature of the water if you remove 200 J of heat?
   a) $T = 10$ °C
   b) $T = 20$ °C
   c) $T = 30$ °C
   d) $T = 40$ °C
   e) $T = 50$ °C

Since $mC\Delta T = Q$ and you are removing twice the heat then the temperature should decrease 20 C from 50 C.

Top View



The next two questions refer to the diagram to the right and involve two disks on a frictionless level surface. The disks, both initially at rest, are pushed with the same force for the same distance. The black disk has more mass than the white disk.

Side View

7. [4 PTS] Which disk has a greater change in momentum when it crosses line B?
   a) The white disk has a greater change in momentum.
   b) The black disk has a greater change in momentum.
   c) Both disks have the same change in momentum.
   d) Not enough information.

Momentum and energy can be related, $|\vec{p}| = \sqrt{2mKE}$, so since change in kinetic energy is the same the more massive disk has more momentum.

8. [4 PTS] Which disk has a greater change in energy when it crosses line B?
   a) The white disk has a greater change in energy.
   b) The black disk has a greater change in energy.
   c) Both disks have the same change in energy.
   d) Not enough information.

Work is the change in energy. $W = \sum \vec{F} \cdot \Delta\vec{x} = \Delta KE$

9. [6 PTS] A satellite is in a circular orbit around a planet. The satellite is moved into an orbit closer to the planet while conserving its total energy. Indicate which of the following statements about this satellite are **T**rue and which are **F**alse. Explain.
   a) __F__ The satellite's kinetic energy decreases
   b) __T__ The satellite's kinetic energy increases
   c) __F__ The satellite's potential and kinetic energy stay constant
   d) __T__ The satellite's potential energy decreases
   e) __F__ The satellite's potential energy increases

Energy is conserved and since potential energy, $PE_g = -\frac{GMm}{r}$, is decreasing the kinetic energy must increase.

Please do the next two problems using problem solving sheets (or on additional paper).

10. [12 PTS] You have a cool new rocket launcher that uses a spring to propel a rocket into the air. Your rocket (m = 0.12 kg) was launched 25 meters straight up when the spring was compressed 15 cm. You would like to double the launch height. Determine the total force needed to compress the spring to launch the rocket to 50 meters. Note: Create a general formula to maximize credit.

Compress spring 21.2 cm with 554 N since $F = \frac{2mg\sqrt{h_1 h_2}}{x_1}$

11. [12 PTS] Suppose you want to warm up a liter of water on a stove. You put the water in a pot on a 2kW stove element. The water takes 400 seconds to change from $T = 20$°C to $T = 50$ °C. If putting a cover on the pot reduces the power leaking out in half, how long will it take raise the water another $\Delta T = 30$ °C ?

Use $mC\Delta T = (P_{in} + P_{out})\Delta t$ and find P_{out} then divide in half and find Δt=109 sec

Note: 1 liter = 1000 ml, 1 ml = 1 cm^3, the density of water is 1 g/cm^3 and the specific heat of water is 4.2 J/K per gram.

Possibly useful mathematical relationships:

$$\sin^2(\theta) + \cos^2(\theta) = 1 \qquad \sin(2\theta) = 2\sin(\theta)\cos(\theta)$$
$$\cos(2\theta) = \cos^2(\theta) - \sin^2(\theta) = 2\cos^2(\theta) - 1 = 1 - 2\sin^2(\theta)$$

Derivative of a polynomial $\frac{d}{du}Cu^n = nCu^{n-1}$

Anti-derivative (integral) of a polynomial $\int Cu^n du = \frac{1}{n+1}Cu^{n+1} + const.$

The Chain Rule $\frac{d}{dz}f(u) = \frac{d}{dz}u\frac{d}{du}f(u)$

Useful Data:

Mass of Earth = $6\text{x}10^{24}$ kg
Radius of the Earth = $6.4\text{x}10^{6}$ m
G = $6.67\text{x}10^{-11}$ Nm^2/kg^2
Acceleration due to gravity at the surface of the earth is 9.81 m/s^2