Problem Set #5 due beginning of class, Monday, Oct. 27. 100 pts. total

2 pts extra credit per extra person in the group – up to 8 points possible!

3 pts extra credit if you don't use a calculator: if so, write and sign a statement at the top of the problem set: "I [your name] did not use a calculator for any part of this problem set."

#1 You need to build a massive slingshot that propels a 100 kg object (you in a capsule) at 12 km/s so you can go into space (infinity)! For ***each question***, start with a statement of which of the 4 mechanics concepts is central to this problem and why.

a) How fast would you be going when you got to deep space?

b) How fast would you be going as you pass the moon's orbit? *Some folks have brought up a very insightful point: if we approach the moon, then our speed will increase because of the decrease of potential energy, no? This would be very interesting to include. However, I only meant when you cross the moon's* ORBIT. *You are free to presume that the moon is still very far away, somewhere else on the orbit.*

c) What would your acceleration be as you are passing the moon from the pull of the earth's gravity?

d) If your slingshot is a massive spring that compresses 10 m, please find the spring constant that gives you this speed.

e) What would be the maximum acceleration of your body at launch? How would this work for you?

#2 You see below a potential energy diagram for a **2 kg mass**, as a function of displacement. (positive x is to the right). The mass **starts out at x=0 moving at 2 m/s** to the left. *There may be more than one correct answer. In this case, list all correct answers.*

a) Label stable equilibria with "S". You know equilibrium is where a=0. Stable means if you put it there, it will stay there: if it moves a little bit, it will come back.

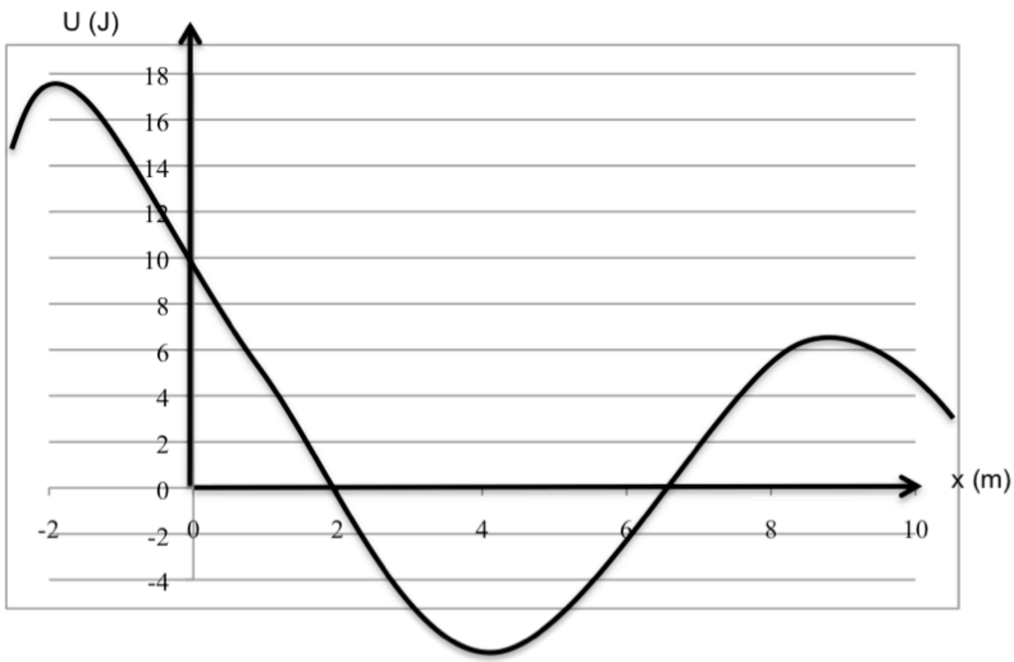
b) Label unstable equilibria at with "U"

c) Label any turning points with "T"

d) what is its speed at x = 6m?

e) What is the approximate acceleration of the mass at x = 6m?

Include direction in your answer, with a unit vector or an arrow.



#3. There are two planets with centers 10^6 m apart: Planet A, and Planet B. The radius of Planet A is twice that of planet B, or $r_A=2r_B$. Both planets are made of the same rocks, and therefore have the same density. There are no other objects. *Provide reasons for your answers before showing the work, before showing the answer.*

a) What is the ratio of the masses of the planets? $m_A=$__m_B .
b) What is the ratio of the force of gravity from one planet acting on the other planet? $F_A=$__F_B .
c) What is the ratio of the acceleration of each object due to gravity between them? $a_A=$__a_B .
d) I want to put myself between the two planets so that there is no force acting on me. That is, the force of gravity from each planet should be equal and opposite. What should the ratio of these distances (from the center of the planets) be? $x_A=$__x_B
e) I want to put myself between the two planets such that my gravitational potential energy due to each planet is the same. What should the ratio of these distances (from the center of the planets) be? $x_A=$__x_B
f) Find x_A (my distance from the center of planet A) in meters for question d) and for question e)
g) If I let the planets fall together, when they hit, what is the ratio of the two speeds? $v_A=$__v_B *be careful to identify which of the 4 concepts is at play here!*
h) (*extra credit*). If planet b) has a radius of 10^4 m and the same density of the planet earth, find the *actual* speeds of each planet immediately before they hit each other.

#4 Solve the infamous "catching the bus" problem. The bus is at your stop, and you're running at a constant speed of 7 m/s from behind in order to catch it. However, just when you're 20 m behind it (or behind the bus driver to be exact), the bus begins accelerating away from you at 1 m/s^2, and will continue accelerating at 1 m/s^2 unless you can meet eyes with the driver. Set up the problem properly with the right equations, substitution, solving the problem, and only at the end substituting the values in and solving the problem while canceling units properly.

a) Do you catch the bus? If so, at what time? If not, how close do you come?
b) Draw the displacement – time, and velocity – time graphs. Graph yourself and the bus together on each graph.
c) Repeat the above problem with the difference that the bus starts when you are 30 m behind it.