MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Physics

Physics 8.01T **Fall Term 2004**

Problem Set 7: Potential Energy, Change in Mechanical Energy

Available on-line October 15; Due: October 26 at 4:00 p.m.

Please write your name, subject, lecture section, table, and the name of the recitation instructor on the top right corner of the first page of your homework solutions. Please place your solutions in your lecture section table box.

Oct 15

Hour One: Problem Solving Session 9: Work Done by Friction and other Dissipative Forces; Motion With Dissipative Forces
Reading: YF 5.3, 6.1-6.4

Problem Set 6: Due Tues Oct 19 at 4:00 pm.

Oct 18

Hour One: Potential Energy
Reading: YF 7.1-7.5

Hour Two: Problem Solving Session 10: Potential Energy
Reading: YF 7.1-7.5

Oct 20

Hour One: Problem Solving Session 11: Energy Techniques
Reading: YF 7.1-7.5

Hour Two: Experiment 6: Conservation of Energy
Reading: Experiment 6

Oct 22

Hour One: Problem Solving Session 12: Conservation of Energy: Restoring Forces and Harmonic Motion
Reading: YF 13.1-13.5

Problem Set 7: Due Tues Oct 26 at 4:00 pm.

Oct 25

Hour One: Center of Mass, Momentum, Impulse and Newton's Second Law
Reading: YF 8.1-8.5

Hour Two: Problem Solving Session 13: Center of Mass, Momentum, Impulse and Newton's Second Law
Reading: YF 8.1-8.5

Oct 27
Hour One: Test Review

Hour Two: **Test Review**

Oct 28 QUIZ TWO: Newton's Laws, Circular Motion, Static Equilibrium, and Conservation of Energy 7:30-9:30 pm

Oct 29 No Class

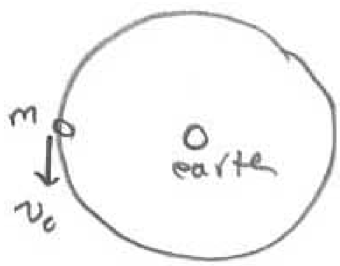
Problem Set 8: Due Tues Nov 2 at 4:00 pm.

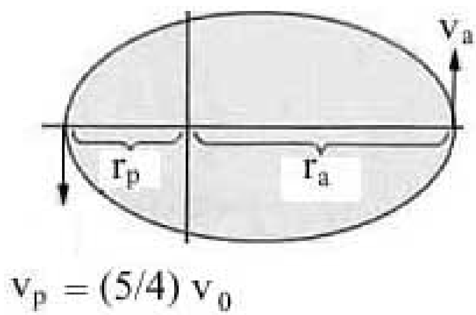
Problem 1: ***Gravitational Potential and Kinetic Energy***

A satellite of mass $m = 5.0\times10^{2}\,kg$ is initially in a circular orbit about the earth with a radius $r_0 = 4.1\times10^{7}\,m$ and velocity $v_0 = 3.1\times10^{3}\,m/s$ around the earth. Assume the earth has mass $m_e = 6.0\times10^{24}\,kg$ and radius $r_e = 6.4\times10^{6}\,m$. Since $m_e >> m$, you may find it convenient to ignore certain terms. Justify any terms you choose to ignore.

a) What is the magnitude of the gravitational force acting on the satellite? What is the centripetal acceleration of the satellite?

b) What are the kinetic and potential energies of the satellite earth system? State any assumptions that you make. Specify your reference point for zero potential energy. What is the total energy?





As a result of a satellite maneuver, the satellite trajectory is changed to an elliptical orbit. This is accomplished by firing a rocket for a short time interval and increasing the tangential speed of the satellite to $(5/4)v_0$. You may assume that during the firing, the satellite does not noticeably change the distance from the center of the earth.

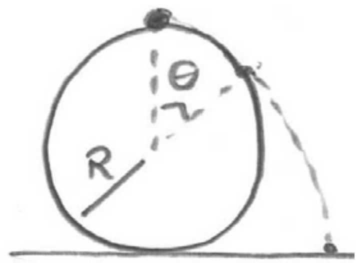
c) What are the kinetic and potential energies of the earth-satellite at the point of closest approach? Specify your reference point for zero potential energy. What is the total energy?

d) How much energy was necessary to change the orbit of the satellite?

e) What speed would the satellite need to acquire so that it can escape to infinity?

Problem 2: ***Conservation of Mechanical Energy and Newton's Second Law***

A small object of mass $m = 0.2\,kg$ is placed at the top of a large sphere of radius $R = 0.5\,m$ resting on the ground. The object is given a negligibly small velocity so that it starts to slide down the sphere. Assume the surface of the sphere is frictionless and the sphere is fixed to the surface of a table. In this problem, you will try to find where the object hits the ground.



a) Briefly describe how you intend to model the motion. Here are some questions which should help guide your thinking. Is there any special condition(s) that describe when the object leaves the sphere? Does the normal force do any work on the object? Does the principle of Conservation of Energy replace Newton's Second Law in the radial direction or are they independent?

b) At what angle will the mass leave the sphere?

c) What is the velocity of the mass when it just leaves the sphere?

d) How far from the bottom of the sphere will the mass hit the ground?

Problem 3: ***Conservation of Energy and Newton's Second Law: Tetherball***

A ball of negligible radius and mass $m = 0.1\,kg$ hangs from a string of length $l = 0.5\,m$. It is hit in such a way that it then travels in a vertical circle (with negligible loss of energy). The initial speed of the ball after being struck is $v_0 = 7.0\,m/s$.

a) Find the speed of the ball at the top of the circle.

b) Find the tension in the string when the ball is at the top of the circle.

Problem 4: ***Spring-mass harmonic oscillator***

Consider an ideal spring that has an unstretched length l_0. Assume the spring has a constant k. Suppose the spring is attached to a mass m that lies on a horizontal frictionless surface. The spring-mass system is compressed a distance of x_0 from equilibrium and then released with an initial speed v_0 toward the equilibrium position.

a) What is the period of oscillation for this system?

b) How long will it take for the mass to first return to the equilibrium position?

c) How long will it take for the mass to first become completely extended?

d) Draw a graph of the position and velocity of the mass as a function of time. Carefully label your axes and clearly specify any special values.

Problem 5: Analysis Experiment 06 Post

a) Enter the values from your experiment into the table below.

a_{up} (m/s^2)	a_{down} (m/s^2)	$U(h_1)$ (mJ)	$U(h_2)$ (mJ)

Use these numbers, along with M = 0.75 kg, to calculate the friction force on the cart. Compare it with the value you obtained from the potential energy difference between the turning points h_1 and h_2.

b) Explain briefly in words why it makes sense to fit the function $A \sin[2\pi(x-C)/T]$ to the force peaks when the cart bounces off the spring on the force sensor.

c) Enter the results of your fit to the second bounce into this table:

A (N)	k (N/m)	A^2/2k (mJ)

and use them to find the force constant of the spring. Compute the potential energy stored in the compressed spring, $A^2/2k$, and compare it with the average of $U(h_1)$ and $U(h_2)$ from the table above.