Physics 121 - Test 2

July 24, 2009

You have 90 minutes to complete this test. Do all of your work on separate sheets of paper. You may use your calculator and one 3"x5" notecard of equations. Please show ALL of your work to receive full credit (free body diagrams, equations, etc.). Include units in your answers where appropriate. Try all parts of the questions, if you get stuck, write as much information as you know (concepts, equations, etc.) and what you think you should do. Partial credit available!

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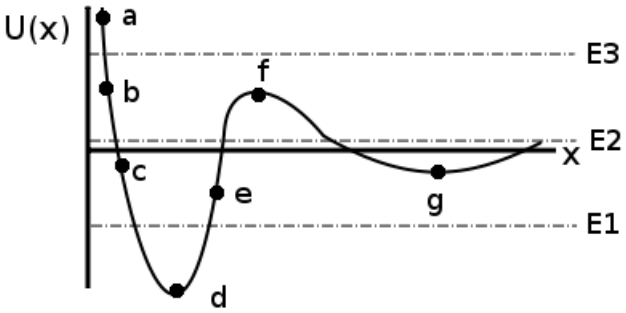
1. Equation 1 describes the potential energy as a function of position for a particle.

$$U(x) = \frac{2}{7}x^{\frac{5}{2}} - \frac{1}{3}x \tag{1}$$

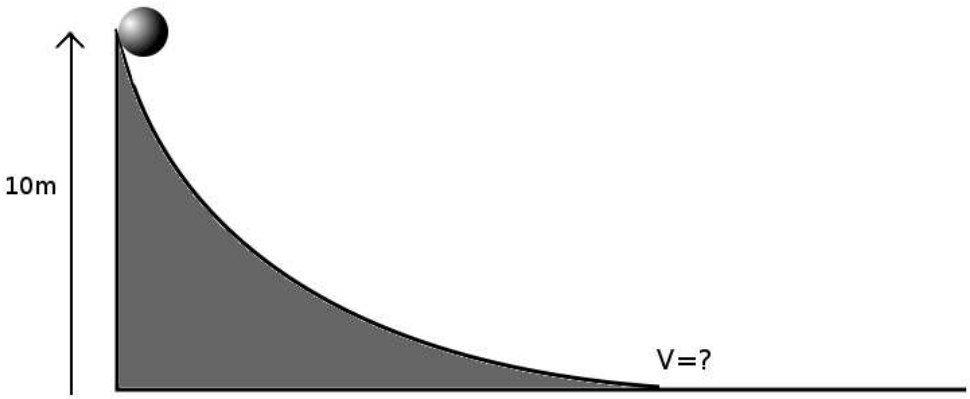
a) What is the force as a function of position?
b) What is the force on the particle when it's at x=3m?

2. A particle moves along the x-axis while acted on by a single conservative force. the potential that corresponds to the force is shown below. There are three possible total energies of the particle, given by the dotted lines in the figure.



a) Which point(s) can the particle inhabit if the total energy of the system is E1?
b) If the system has total energy E2 and starts with the potential at point c, is it possible for the particle to move to point g?
c) Which of the labeled points show where the particle is experiencing the greatest negative force?

3. A ball starts at rest at the top of a 10m tall ramp. It is released and rolls without slipping to the bottom of the ramp. What is the velocity of the center of mass of the ball when it reaches the bottom? The ball can be modeled as a spherical shell with radius 0.2m and mass 1.2kg.



4. What is the total orbital energy of Jupiter as it orbits the Sun? Assume a circular orbit. Some useful numbers:
$M_{Sun} = 1.99 \times 10^{30} kg$
$M_{Jupiter} = 1.9 \times 10^{27} kg$
$G = 6.67 \times 10^{-11} Nm^2/kg^2$
$R_{S-J} = 7.78 \times 10^{11} m$

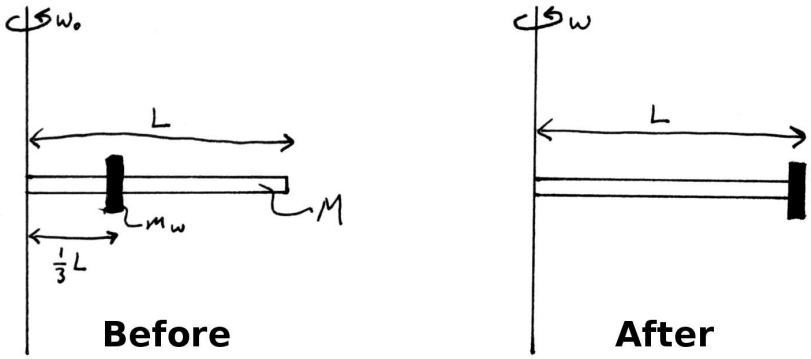
5. Find the center of mass of the following system: A 3kg mass located at $(-5\hat{i} + 0\hat{j})$ m, a 4kg mass located at $(-3\hat{i} + 3\hat{j})$ m, a 2kg mass located at $(0\hat{i} + 6\hat{j})$ m and a 5kg mass located at $(5\hat{i} + 0\hat{j})$ m.

6. A 75kg astronaut (this includes the mass of their suit, but not their tools) is floating motionless in space relative to a space station. Out of propellant, the astronaut is stranded with only their tool belt. In the belt is a 1.3kg wrench set and a 4kg electric drill. The astronaut can throw each of these at 2.4m/s.
a) What direction should the astronaut throw the tools to make it back to the space station? (You can use generalized directions or draw a picture).
b) What is the astronauts new speed relative to the space station after throwing both tools?

7. A standard door is about 1.2m by 2.1m. It is a heavy entry door that has a mass of 50kg.
a) What is its moment of inertia? (numerical value).
b) What force do I need to apply on the outer edge of the door (perpendicular to the surface of the door) so that it has an angular acceleration of $0.5 rad/s^2$?

8. Which of the following is a true statement?
a) It is possible to place a stellite in a circular orbit above the earth's equator, but it is not possible to place a satellite in a circular "polar" orbit, i.e. and orbit that takes the satellite over both the north and south poles of the earth.
b) the fact that planet X in the solar system is farther from the sun than is planet Y does not mean that the orbital period of X is greater than Y.
c) The Earth is in free fall under the action of the net gravitational force of the Sun and the planets.
d) It is possible to place communications satellites in stationary orbits such that they always remain directly above (i.e. radially out from) any desired point on earth.

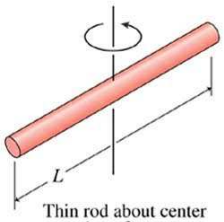
9. A slender rod with a sliding weight on it has mass M, length L and is freely rotating about one end with angular speed ω_0. The weight, mass m_w, starts out $\frac{1}{3}$ of the total length out from the axis of rotation, then is allowed to slide out to the end of the rod, a distance L away from the axis of rotation.



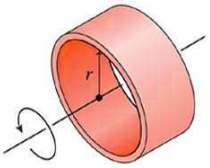
a) What is the angular speed ω of the system when the weight has moved all the way to the end of the rod? Treat the weight as a point mass and express your answer in terms of M, L, ω_0 and m_w. *(Hint: find the total moment of inertia of the system in both situations.)*

b) Does the angular speed increase or decrease?

TABLE 10.2 Rotational Inertias

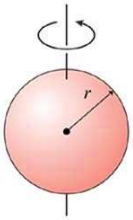


Thin rod about center
$I = \frac{1}{12}ML^2$

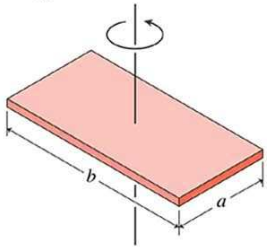


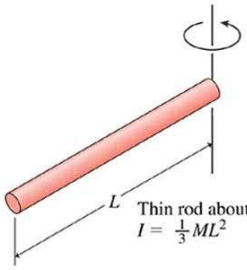
Thin ring or hollow cylinder about its axis
$I = MR^2$

Solid sphere about diameter
$I = \frac{2}{5}MR^2$

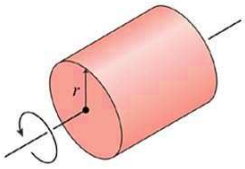


Flat plate about perpendicular axis
$I = \frac{1}{12}M(a^2 + b^2)$



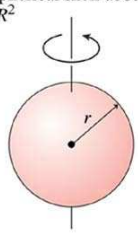


Thin rod about end
$I = \frac{1}{3}ML^2$



Disk or solid cylinder about its axis
$I = \frac{1}{2}MR^2$

Hollow spherical shell about diameter
$I = \frac{2}{3}MR^2$



Flat plate about central axis
$I = \frac{1}{12}Ma^2$