Lab: AP Review Sheets

AP Physics

Chapter 8 - Potential Energy & Conservation of Energy

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Background: This unit is focused on the different ways energy can be stored, conservation forces, nonconservative forces, and playing around with the conservation of energy equation.

Key Terms and Topics

1. The main ways energy can be stored is through gravitational potential energy and elastic potential energy

2. For the h in the gravitational potential energy equation, $h = 0$ can be at any point that you wish, and all heights will be then measured relative to that

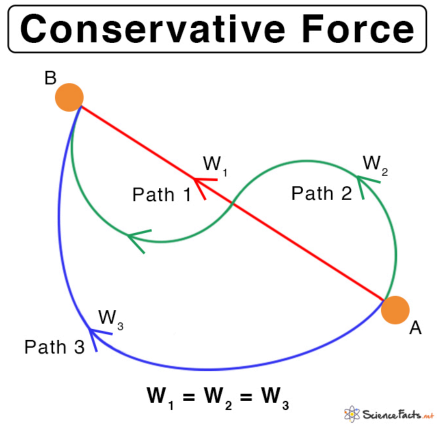
3. When a gravitational or spring force does work on an object, the potential energy decreases proportionally to the work done

4. Forces are conservative if work done between two points is the same regardless of the actual distance traveled (i.e. gravitational and elastic).

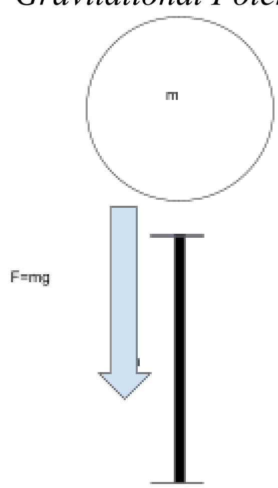
5. The mechanical energy of a system is the kinetic energy and potential energy added together.

6. The mechanical energy of a system remains constant when only conservative forces do work, but when there are non-conservative forces in a system, total energy remains the same

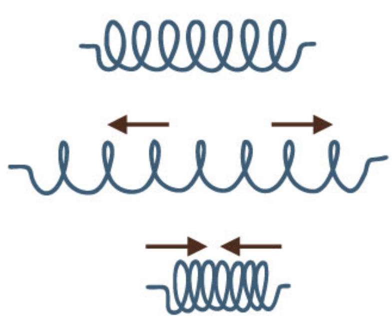
Diagrams



Gravitational Potential Energy



Elastic Potential Energy



Equations

$$U_g = mgh$$

$$U_s = \frac{1}{2}kx^2$$

$$W = -\Delta U$$

$$W = \int_{x_i}^{x_f} F \cdot dx$$

$$\Delta U = -\int_{x_i}^{x_f} F \cdot dx$$

$$W = -F_{friction} \cdot x$$

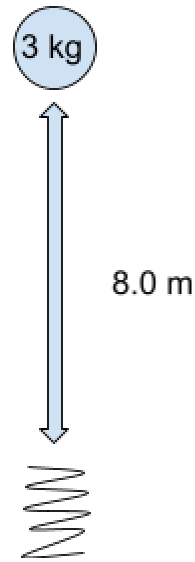
$$\Delta E_{internal} = f_k d$$

$$\Sigma E_i = \Sigma E_f$$

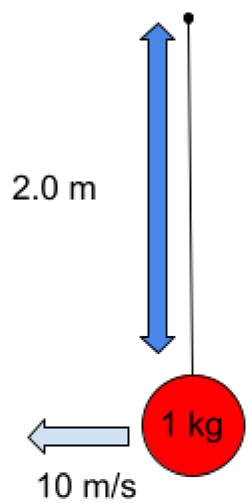
$$E_{mechanical} = K + U$$

$$F = -\frac{dU}{dx}$$

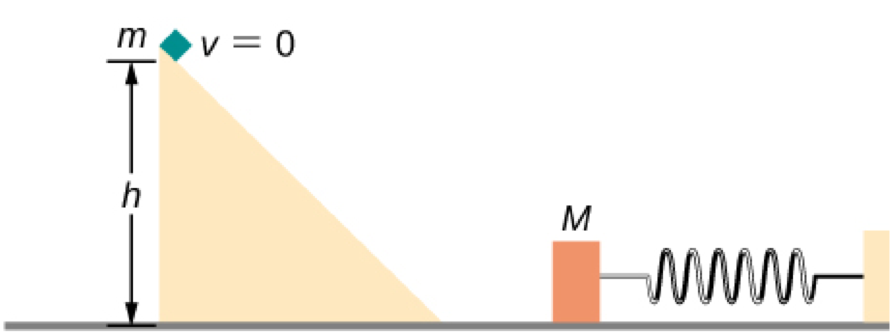
1. How much is a spring with a spring constant of 800 N/m compressed when a ball of mass 3.0 kg is dropped from 8 meters above?



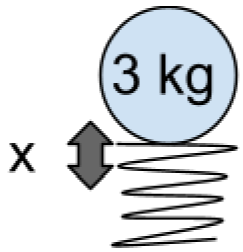
2. A 1.0-kg ball at the end of a 2.0-m string swings in a vertical plane. At its lowest point the ball is moving with a speed of 10 m/s. (a) What is its speed at the top of its path? (b) What is the tension in the string when the ball is at the bottom and at the top of its path?



3. A block of mass m, after sliding down a frictionless incline, strikes another block of mass M that is attached to a spring of spring constant k (see below). The blocks stick together upon impact and travel together. Find the compression of the spring in terms of m, M, h, g, and k when the combination comes to rest.



1. This problem is a simple potential energy transfer, the gravitational potential energy of the ball is transferred into kinetic energy, which is then used to compress the spring a distance x. The kinetic energy does not need to be solved, so the problem can be solved by finding the gravitational potential energy and setting that equal to the spring potential energy and finding x from that.



$$U_g = mgh \qquad U_s = \frac{1}{2}kx^2$$

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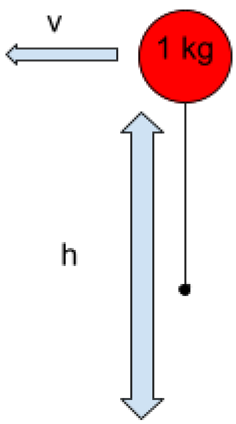
$$(3\ kg)(9.81)(8.0\ m) = \frac{1}{2}(800\ N/m)x^2$$

$$x = 0.767\ m$$

2. This problem focuses on the conservation of mechanical energy. At the bottom, the mechanical energy is all kinetic energy, but as it rises higher, more and more kinetic energy is transformed into gravitational potential energy. Part B uses force analysis in conjunction with centripetal force.
    a. The ball moves up a distance h, which is equal to 2r, or 4 meters.



$$\Delta E_{mechanical} = K + U$$

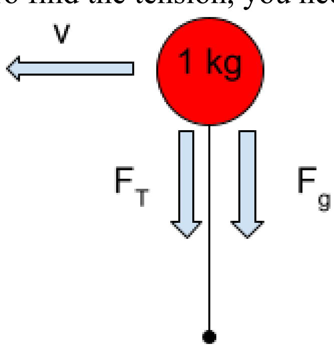
$$K_i + U_i = K_f + U_f$$

$$\frac{1}{2}mv_i^2 + 0 = \frac{1}{2}mv_f^2 + mgh$$

$$(\frac{1}{2})(1.0\ kg)(10\ m/s)^2 = (\frac{1}{2})(1.0\ kg)v_f^2 + (1.0\ kg)(9.81)(4.0\ m)$$

$$v_f = 4.64\ m/s$$

    b. To find the tension, you need to do a force analysis at the two different points



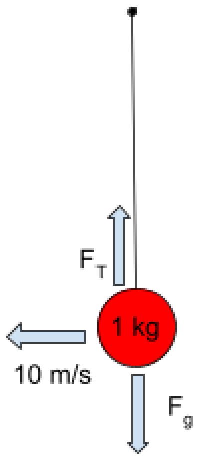
$$F_{net} = ma$$

$$F_{T-top} + F_g = ma_c$$

$$F_{T-top} = m\frac{v^2}{r} - mg$$

$$F_{T-top} = (1.0\ kg)\frac{(4.64\ m/s)^2}{2} - (1.0\ kg)(9.81)$$

$$F_{T-top} = 0.95\ N$$



$F_{net} = ma$

$F_{T-bottom} - F_g = ma_c$

$F_{T-bottom} = m\frac{v^2}{r} + mg$

$F_{T-bottom} = (1)\frac{(10)^2}{2} + (1)(9.81)$

$F_{T-bottom} = 59.8\,N$

3. Though this is not strictly of this unit, this question also has to do with collisions, more specifically a perfectly inelastic collision.

Mass at the top has potential energy mgh which is then transferred into kinetic energy.

$U = mgh$ $\quad K_i + U_i = K_f + U_f$ $\quad 0 + mgh = \frac{1}{2}mv^2 + 0$ $\quad v = \sqrt{2gh}$

The next part of the problem is momentum and conservation of momentum

$p = mv$ $\quad p = m\sqrt{2gh}$ $\quad p = \sqrt{2m^2gh}$ $\quad m_1v_1 + m_2v_2 = (m_1 + m_2)v'$

$\sqrt{2m^2gh} + M(0) = (m + M)v'$ $\quad v' = \frac{\sqrt{2m^2gh}}{(m+M)}$

Now with the velocity of the two masses joined together, you can convert kinetic energy into elastic potential energy in order to find distance

$\frac{1}{2}mv^2 = \frac{1}{2}kx^2$ $\quad \frac{1}{2}(m + M)(\frac{\sqrt{2m^2gh}}{(m+M)})^2 = \frac{1}{2}kx^2$ $\quad x = \sqrt{\frac{2m^2gh}{k(m+M)}}$