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Physics

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Conservation of Energy Problems

The Fruit and Fun amusement park boasts "the world's orangest roller coaster," which is so bright orange, it makes you dizzy just to look at it. The coaster goes from the highest point of the track, point A, with a speed of 3.5 m/s. If $h_A$ = 60.0 m and $h_B$ = 30.0 m, what is the coaster's speed at point B? The coaster has a mass of 528.4 kg, and friction and air resistance are negligible.

a. Find $\triangle U_g$:

   $\triangle U_g = |mg|h_B - |mg|(h_B - h_A)$

   $\triangle U_g = |(528.4 \text{ kg})(-9.81 \text{ m/s}^2)|(30.0 \text{ m} - 60.0 \text{ m})$

   $\triangle U_g = -155{,}508.12 \text{ J}$

b. Find $\triangle K$:

   $\triangle K = -\triangle U_g = -(-155{,}508.12 \text{ J})$

   $\triangle K = +155{,}508.12 \text{ J}$

c. Solve for $v_B$:

   $\triangle K = ½mv_B^2 - ½mv_A^2$

   $\triangle K = ½m(v_B^2 - v_A^2)$

   $v_B^2 - v_A^2 = 2(\triangle K)/m + v_A^2$

   $v_B^2 = (2(\triangle K)/m) + v_A^2$

   $v_B = \sqrt{([(2[\triangle K])/m] + v_A^2)} = \sqrt{([(2[155{,}508.12 \text{ J}]) / 528.4 \text{ kg}] + 3.5 \text{ m}^2/\text{s}^2)}$

   $v_B = 24.3 \text{ m/s}$

All the bees in a hive decide to work together to pull a flower pot from someone's porch up a hill and to their hive. The pot has a mass of 3.2 kg, and the hill is 13.4 m high, and has a hypotenuse with a length of 57.2 m. The hill is covered in slippery, frictionless grass.

a. What is the Ideal Mechanical Advantage provided by the hill as a ramp?

   $IMA = d_{in} / d_{out}$

   $IMA = 57.2\ m / 13.4\ m$

   IMA ~= 4.27

b. How much force do the bees need to exert in order to move the flower pot?

   $IMA = F_{out} / F_{in}$

   $F_{out}$ is the weight of the flower pot. Rearrange to solve for $F_{in}$:

   $F_{in} = F_{out} / IMA = |mg| / IMA = |(3.2\ kg)(-9.81\ m/s^2)| \backslash 4.27$

   $F_{in} = 7.35\ N$

<u>I was unable to think of an original situation for Example 10-4, so I simply used the original</u>

A physics student sets up the block and tackle system shown in figure 10-25 and attaches a 10 N spring scale to the free end of the string. The load for his experiment is a 1 kg laboratory mass that is hooked to the bottom pulley. He slowly pulls down on the free end of the string until the mass is suspended by the tackle and is hanging motionless. The spring scale indicates 3.30 N. He then lowers the mass to the tabletop, unhooks it from the apparatus, and weighs it with the spring scale. The mass weighs 9.82 N. (a) What is the ideal mechanical advantage of the pulley system? (b) what is the actual mechanical advantage? (c) What is the efficiency of the system?

Solution:

a. From Figure 10-25, you can see that there are three strings supporting the mass and lower pulley, so the IMA for the system is 3.

b. The AMA is the ration of $F_r$ to $F_e$. The effort force is $F_e = 3.30$ N. The resistance force is the weight of the mass, $F_r = 9.28$ N. Using Equation 10.8, you can find the AMA:

   $AMA = F_r / F_e = 9.82\ N / 3.30\ N$

   $AMA \simeq 2.975 \simeq 2.98$

c. The efficiency is calculated by Equation 10.9:

$$n = (AMA / IMA)(100\%)$$

$$n = (2.975 / 3)(100\%)$$

$$n \simeq 99.16\% \simeq 99.2\%$$