Name KEY
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Conservation of Energy Problem Set

For each problem, sketch a diagram and label the types of energy at each point mentioned in the problem. This WILL help you solve the problems.

1. A bird is flying with a speed of 18 m/s over water when it accidentally drops a 2.00 kg fish. Assuming the altitude of the bird is 5.40 m and disregarding friction, what is the speed of the fish when it hits the water?

18 m/s

5.4 m

$E_k + E_g = E_T = \frac{1}{2}mv^2 + mgh$

$= \frac{1}{2}(2)(18^2) + (2)(5.4)(9.8)$

$= 324 + 105.84$

$= 429.84\ J$

$E_k = E_T$

$429.84 = \frac{1}{2}(2)(v^2)$

$\sqrt{429.84} = v$

$\boxed{v = 20.73\ m/s}$

2. Bonny Blair of the United States set a world record in speed skating when she skated 5.00×10^2 m with an average speed of 12.92 m/s. Suppose Blair crossed the finish line at this speed and then skated freely until her speed was 8.00 m/s. If Blair's mass was 55.0 kg, how much work was done by friction?

$\Delta x = 5 \times 10^2\ m$

$v_i = 12.92\ m/s$

$v_f = 8\ m/s$

$m = 55\ kg$

12.92 m/s — E_k

8.00 m/s — $E_T = E_k + E_f$

$E_T = E_k = \frac{1}{2}(55)(12.92^2)$

$= (27.5)(166.93)$

$E_T = 4{,}590.58\ J$

$= \frac{1}{2}(55)(8^2)$

$= (27.5)(64) = 1760\ J$

$E_f = 4{,}590.58 - 1760$

$\boxed{= 2{,}830.58\ J}$

3. A 755 N diver drops from a board 10.0 m above the water's surface.
   a. Find the diver's speed just before striking the water.

E_g — 10 m — E_k

$E_g = mgh$

$= (755)(10\ m) \boxed{= 7550\ J}$

$m = \frac{F_g}{g} = \frac{755}{9.8} = 77.04\ kg$

$7550 = \frac{1}{2}(77.04)(v^2)$

$7550 = 38.52\ v^2$

$\sqrt{v^2} = \sqrt{196.002}$

$\boxed{v = 14.00\ m/s}$

   b. If the diver leaves the same board with a speed of 2 m/s, what would her speed be when striking the water?

2 m/s — $E_g + E_k$ — 10 m — E_k

$E_T = E_g + E_k = 7550 + \frac{1}{2}(77.04)(2^2)$

$= 7550 + (38.52)(4)$

$= 7550 + 154.08$

$E_T \boxed{= 7704.08\ J}$

$7704.08 = \frac{1}{2}(77.04)\,v^2$

$7704.08 = 38.52\,v^2$

$\sqrt{200} = \sqrt{v^2}$

$\boxed{14.14 = v\ m/s}$

4. A bird sitting on top of a 143 m tree drops a nut. What is the speed of the falling nut at the moment it is 50 m above the ground?

$mgh = mgh + \frac{1}{2}mv^2$

$\cancel{m}gh = \cancel{m}(gh + \frac{1}{2}v^2)$

$(9.8)(143) = [(9.8)(50) + \frac{1}{2}v^2]$

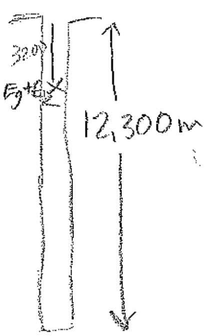
$1401.4 = 490 + \frac{1}{2}v^2$

$2(911.4) = \cancel{\frac{1}{2}}v^2$

$\sqrt{1822.8} = \sqrt{v^{\cancel{2}}}$

$\boxed{v = 42.69 \text{ m/s}}$

5. The deepest mine ever drilled has a depth of 12.3 km (Mt. Everest is only 8.8 km tall). Suppose you drop a rock with a mass of 120 g down the shaft of this mine. What would the rock's kinetic energy be after falling 3.2 km? What would the potential energy associated with the rock be at that same moment?



$m = .120 \text{ kg}$

$E_k = ?$

$\Delta x = 3200 \text{ m}$

$E_g = ?$

$12,300 - 3200 = 9,100 \text{ m} = h_1$

$E_g = (.120)(9.8)(9100) = 10,701.6$

$E_T = (12,300)(9.8)(.120)$

$\boxed{E_T = 14,464.8}$

$E_T = E_g + E_k$

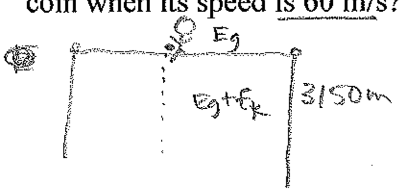
$E_T = \underbrace{(.120)(9.8)(9100)}_{mgh} + E_k$

$\boxed{E_g = 10,701.6 \text{ J}}$

$E_k = E_T - E_g$

$= 14,464.8 - 10,701.6 = \boxed{3,763.2 \text{ J}}$

6. In 1989, Michel Menin of France walked a tightrope 3150 m above the ground. Suppose a coin with a mass of 5 g falls from Menin's pocket during his walk. What potential energy is associated with the coin when its speed is 60 m/s?



$E_g = mgh$

$= (.005 \text{ kg})(9.8)(3150)$

$\boxed{E_T = 154.35 \text{ J}}$

$E_T = E_g + E_k$

~~154.35 = (.005)(9.8)~~

$E_k = \frac{1}{2}(.005)(60^2)$

$= (.0025)(3600)$

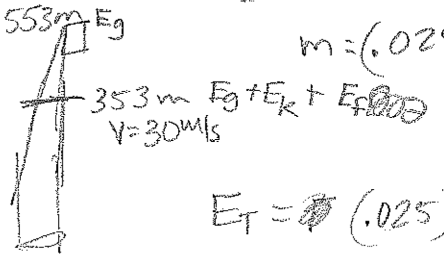
$= 9 \text{ J}$

$E_g = E_T - E_k$

$= 154.35 - 9$

$\boxed{= 145.35 \text{ J}}$

7. The CN Tower in Toronto, Canada, is 553 m tall, making it the tallest free-standing structure in the world. Suppose a chunk of ice with a mass of 25.0 g falls from the top of the tower. The speed of the ice is 30.0 m/s as it passes the restaurant in the tower located 353 m above the ground. What is the average force due to air resistance?



$m = (.025\ kg)(9.8)(553)$

$E_T = 135.49\ J$

$W_a = F\Delta x$

$E_T = (.025)(9.8)(353) + \frac{1}{2}(.025)(30^2) + W_a$

$E_T = 86.49 + (.0125)(900) + W_a$

$135.49 = 86.49 + 11.25 + W_a$

$135.49 = 97.74 + W_a$

$\boxed{37.75\ J = W_{air}}$

$\frac{37.75}{200} =$

8. In 1979, Dr. Hans Liebold of Germany drove a race car 12.6 km with an average speed of 404 km/h. Suppose Dr. Liebold applied the brakes to reduce his speed. What was the car's final speed if 3.00 MJ of work was done by the brakes? Assume the mass of the car and driver to be 8.00×10^2 kg.

$m = 800\ kg$

$\Delta x = 12.6\ km$

$W = E_f = 3{,}000{,}000\ J$

$V_i = 404\ km/hr = 112.2\ m/s$

$V_f = ?$

$\frac{404\ km}{1\ hr} \cdot \frac{1000\ m}{1\ km} \cdot \frac{1\ hr}{60\ min} \cdot \frac{1\ min}{60\ sec} = 112.2\ m/s$

$E_k = \frac{1}{2}mv^2$

$= \frac{1}{2}(800)(112.2)^2$

$= (400)(12{,}593.83)$

$E_T = E_{k_1} = 5{,}037{,}530.86$

$E_T = E_{k_2} + W_B$

$E_T = \frac{1}{2}mv^2 + W_B$

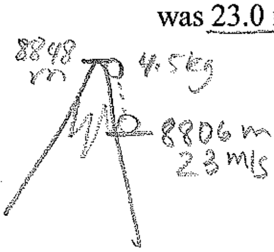
$5{,}037{,}530.86 = \frac{1}{2}800v^2 + 30000$

$2{,}037{,}530.86 = 400v^2$

$5{,}093.83 = v^2$

$\boxed{71.37 = V\ m/s}$

9. The summit of Mount Everest is 8848.0 m above sea level, making it the highest summit on Earth. In 1953, Edmund Hillary became the first person to reach the summit. Suppose that upon arriving at the summit, Hillary slid a rock with a mass of 4.50 kg down the side of the mountain. If the rock's speed was 23.0 m/s when it was 8806.0 m above sea level, how much work was done on the rock by friction?



$E_T = E_g = (4.5)(9.8)(8848)$

$E_T = 390{,}196.8\ J$

$E_T = E_g + E_k + W_f$

$E_T - E_g - E_k = W_f$

$W_f = 390{,}196.8 - (4.5)(9.8)(8806) - \frac{1}{2}(4.5)(23^2)$ $(2.25)(529)$

$= 390{,}196.8 - 388{,}344.6 - 1{,}190.25 = \boxed{661.95\ J}$

10. In 1990, Roger Hickey of California reached a speed of 35.0 m/s on his skateboard. Suppose it took 26 kJ of work for Hickey to reach this speed from a speed of 25.0 m/s. Friction resisted the motion with 5kJ of work. Calculate Hickey's mass.

$m = ?$

$V_f = 35 \text{ m/s}$

$W_{in} = 26{,}000 \text{ J}$

$V_i = 25 \text{ m/s}$

$W_f = 5{,}000 \text{ J}$

$E_{K_i} + W_{in} = W_f + E_{K_f}$

$\frac{1}{2}mv^2 + W_{in} = W_f + \frac{1}{2}mv^2$

$\frac{1}{2}m(25)^2 + 26{,}000\text{J} = 5{,}000\text{J} + \frac{1}{2}m(35)^2$

$-5000 \qquad -5000$

$\frac{1}{2}m(625) + 21{,}000\text{J} = \frac{1}{2}m(1225)$

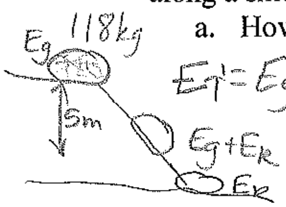
$21{,}000 = 612.5m - 312.5m$

$21{,}000 = 300m$

$\frac{21{,}000}{300} = m = \boxed{70\text{ kg}}$

11. The largest watermelon every grown had a mass of 118 kg. Suppose this watermelon is exhibited on a platform 5 m above the ground. After the exhibition, the watermelon is allowed to slide to the ground along a smooth (frictionless) ramp.

a. How high above the ground is the watermelon at the moment its kinetic energy is 4.61 kJ?



$E_T = E_g = mgh = (118)(9.8)(5)$

$= 5{,}782 \text{ J}$

$E_T = mgh + 4610\text{ J}$

$5782 = (118)(9.8)(h) + 4610\text{J}$

$1172 = 1156.4h$

$\boxed{1.01\text{m} = h}$

b. How fast is the watermelon going when it reaches the bottom of the ramp?

$5782 = \frac{1}{2}(118)(v^2)$

$5782 = 59v^2$

$98 = v^2$

$\boxed{9.9 = v \text{ m/s}}$

c. If the watermelon slides for 6 m on the (not-so-frictionless)ground after it reaches the bottom of the ramp, what is the coefficient of friction between the ground and the melon?

Δx

$F_N = F_g$

$F_f = \mu F_N$

$F = ma$

$V_i = 9.9 \text{ m/s}$

$V_f = 0 \text{ m/s}$

$\Delta x = 6\text{ m}$

$a = ?$

$V_f^2 = V_i^2 + 2a\Delta x$

$\frac{V_f^2 - V_i^2}{2\Delta x} = a = \frac{0^2 - 9.9^2}{2(6)}$

$= \frac{98.01}{12} = 8.17 \text{ m/s}^2$

$F = ma$

$= (118)(8.17)$

$= 963.77\text{N}$

$F_g = (118)(9.8)$

1156.4

$F_f = \mu F_N$

$\mu = \frac{F_f}{F_N} = \frac{963.77\text{N}}{1156.4\text{N}} = \boxed{.833}$