Efficiency and Heat Energy

Efficiency is a ratio of USEFUL output energy / total INPUT energy.

The only challenge you ever face, is figuring out what the input is, and what is USEFUL output. UNLESS you are using a heater Eh is ALWAYS wasted.

A Ray of mass 70 kg is dropped from height 12 m. He bounces to height 3.0 m, what is the efficiency of the bounce, and how much heat energy was created?

$$\frac{\text{useful output}}{\text{total input}} = \frac{E_{pf}}{E_{po} + E_{ko}} = \frac{mgh_f}{mgh_o} = \frac{3}{12} = 0.25$$

$$E_{ko} + E_{po} = E_{kf} + E_{pf} + E_H$$

$$mgh_o = mgh_f + E_H$$

$$(70)(9.8)(12) = (70)(9.8)(3) + E_H$$

$$8232 = 2058 + E_H \qquad E_H = 6174\text{ J}$$

6170 J

6200 J

A bouncy ball is thrown at 10.0 m/s from height 4.0 m, it bounces up to a height of 8.7 m. What was the efficiency of the bounce?

$$\frac{\text{useful out}}{\text{total in}} = \frac{E_{pf}}{E_{po} + E_{ko}} = \frac{mgh_f}{mgh_o + \frac{1}{2}mv_o^2} = \frac{(9.8)(8.7)}{(9.8)4 + \frac{1}{2}(10)^2} = 0.96$$

A car of mass 2000 kg uses 3.125 x 10 [6] J of energy to accelerate to 90 km/h. $\div 3.6 = \frac{m}{s}$

What is the efficiency of the engine?

(90 km/h → 25; 3.125 x 10⁶ J = total input)

$$Eff = \frac{\text{useful}}{\text{total in}} = \frac{E_{kf}}{3.125 \times 10^6} = \frac{\frac{1}{2} m v_f^2}{3.125 \times 10^6} = \frac{\frac{1}{2}(2000)25^2}{3.125 \times 10^6} = .20 = 20\%$$

A copper ball of mass .50 kg is dropped from height 3.0 m. It bounces to 0.25 m what is a) the efficiency, b) the heat energy produced, c) the Rise in temperature of the ball assuming all heat stays in the copper?

$$Eff = \frac{E_{pf}}{E_{po} + \cancel{E_{ko}}} = \frac{\cancel{mg}h_f}{\cancel{mg}h_o} = \frac{.25}{3} = 0.083$$

$$E_{po} + \cancel{E_{ko}} = E_{pf} + \cancel{E_{kf}} + E_H$$

$$mgh_o = mgh_f + E_H$$

$$(.5)(9.8)(3) = (.5)(9.8)(.25) + E_H$$

$$14.7 = 13.5\text{J} \Rightarrow E_H$$

$$-1.225$$

$$E_H = mc\Delta T$$

$$\frac{(13.5)}{(.5)(385)} = \frac{\cancel{(.5)}\cancel{(385)}\Delta T}{} = 0.07\ ^\circ\text{C} \ \text{K}$$

1 or 2 on °C → K

1 or 2 on Calorimetry ← mix hot w/ cold find T_f

1 or 2 on $E = mc\Delta T$

1 or 2 on heat "lost"

$$E_{po} + E_{ko} = E_{pf} + E_{kf} + E_H$$

1 or 2 on efficiency

A 3.0 kg mass of copper (c=385 J/kgK) at 80°C is placed in 1.5 kg of water (c = 4182 J/kgK) at 40°C. What will be the final temperature?

hot cold

$\Delta E = mc\Delta T + mc\Delta T$

$0 = (3)(385)(T_f - 80) + 1.5(4182)(T_f - 40)$

$0 = 1155 T_f - 92400 + 6273 T_f - 250920$

$0 = 7428 T_f - 343320$

$\frac{343320}{7428} = T_f$

$46^0 C = T_f$

A rock of mass 2.0 kg is dropped from height 10 m, it reaches the ground with velocity of 12 m/s, what was a) the heat energy in falling, b) the efficiency of the drop, c) the rise in the temperature of the rock if c = 1200 J/kg/K?

$E_{po} + E_{ko} = E_{pf} + E_{kf} + E_H$

$mgh_o = \frac{1}{2} m v_f^2 + E_H$

$(2)(9.8)(10) = \frac{1}{2}\, 2\, (12)^2 + E_H$

$196 = 144 + E_H$

-144

$= 52 J$

$Eff = \frac{\text{useful}}{\text{total in}} = \frac{E_{kf}}{E_{po}} = \frac{144}{196} = .73$

$E_H = mc\Delta T$

$52 = 2(1200)\Delta T$

$\Delta T = .02^{\circ}C$