

## Efficiency and work done by $F_f$

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Heat Energy and the work done by  $F_f/F_{air}$ :

Almost always heat energy is wasted energy\*

\*exceptions are: when you want to increase the temperature of something, or the internal molecular energy

Whenever some energy seems "missing" it has been transformed into heat energy par example:

A cat is dropped from height 12m, it has mass 3.0 kg, when 2.0 m from the ground it has velocity 10 m/s  
How much heat energy is evolved in the experiment?

$$h=12m \quad m=3kg \quad @2m \quad v=10 \frac{m}{s} \quad Q=?$$

$$E_{p0} + E_{k0} = E_{pf} + E_{kf} + Q$$

$$3(9.8)(12) + 0 = 3(9.8)(2) + \frac{3(10^2)}{2} + Q$$

$$Q = 144 \text{ J}$$

What was the force of air resistance (Force of friction) during the experiment?

What is  $F_f$ ?

$$W = \Delta E = \Delta Q = (144 - 0)$$

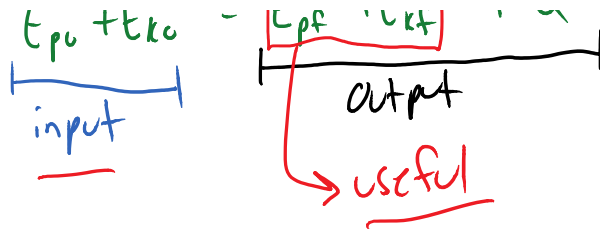
$$= F \cdot d$$

$$144 = F \cdot (2 - 12)$$

$$F_f = -14.4 \text{ N}$$

$$\text{Efficiency} = E_{\text{eff}} = \text{eff} = \frac{\text{useful output}}{\text{total input}} \times 100\%$$

$$E_{p0} + E_{k0} = \underbrace{E_{pf} + E_{kf}}_{\text{input}} + Q$$



Efficiency is a ratio (usually expressed as a percent) of USEFUL energy output over total energy input.

$E_{eff}/eff$

$$Eff = \frac{\text{Useful out}}{\text{total in}} \times 100\%$$

The challenge for you is to determine what is useful output.

A 60 W incandescent (old style) light bulb produces 15 W of radiant (light) energy. What is its efficiency?

60W  $\rightarrow$  15W of light  $eff = ?$

$$eff = \frac{\text{useful output}}{\text{total input}} \times 100\% = \frac{15}{60} = .25 \rightarrow 25\%$$

An EasyBake Oven<sup>®</sup> uses a 60W light bulb to make cupcakes. What is its efficiency?

75%

A 5.0 kg cat is dropped from 20 m height and strikes the ground at 15.0 m/s, how much energy is "lost" as heat, and what was the efficiency of the fall?

5 kg    20m     $V_f = 15 \text{ m/s}$      $Q = ?$      $eff = ?$

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

$$5(9.8)(20) + 0 = 0 + \frac{5(15^2)}{2} + Q$$

total  $978 \text{ J}$       useful

$$Eff = \frac{\text{useful}}{\text{total}} = \frac{\left[ \frac{5(15^2)}{2} \right]}{5(9.8)(20)}$$

$$\overbrace{\quad\quad\quad}^{\text{total}} \quad Q = 418 \text{ J}$$

$$\overbrace{\quad\quad\quad}^{\text{useful}}$$

$$\frac{5(9.8)(20)}{5(9.8)(20)} = .57 \rightarrow 57\%$$

What happened to the rest of the energy?

If the cat were thrown down at 5.0 m/s and reached the ground at 20 m/s what is the new eff.?

$$\text{if } v_0 = 5 \text{ m/s}$$

$$\text{Eff} = \frac{\text{useful out}}{\text{total in}} = \frac{\left(\frac{5(20)^2}{2}\right)}{\left[5(9.8)(20) + \frac{5(5^2)}{2}\right]} = .96 \rightarrow 96\%$$

AND what is the average force of air resistance if the cat has mass  $5.00 \text{ kg}$   $v_0 = 0$

$$W = \Delta E = \Delta Q = (418 - 0)$$

$$W = F \cdot d$$

$$418 = F_f(20)$$

$$F_f = \frac{418}{20} = 20.9 \text{ N}$$

A rocket burns 10 GJ of energy to accelerate to a velocity of 3000 m/s determine its efficiency ( $m = 1500 \text{ kg}$ ).

$$10 \text{ GJ} = 10 \times 10^9 \text{ J}$$

$$v = 3 \text{ km/s}$$

$$m = 1500 \text{ kg}$$

eff = ?

$$\text{eff} = \frac{\left[\frac{1500(3 \text{ km/s})^2}{2}\right]}{10 \times 10^9} = 67.5\%$$

↳ useful

↳ total energy

used.