Efficiency and work done by Ff

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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?

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

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

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

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

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

What is F_f?

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

$$=F\cdot d$$

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

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

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

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

output

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

input — output — useful

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

Eff/eff

Eff = $\frac{\text{Useful out}}{\text{total in}}$ x 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 → 15W of light   eff = ?

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

An EasyBake Oven ® 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?

5kg   20m $V_f = 15\,m/s$ Q = ?   eff = ?

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

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

total — useful

Q = 418 J

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

total $\quad Q = 418\ J \quad$ useful

$$5(9.8)(20)$$

$$= .57 \rightarrow 57\%$$

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.?

if $V_0 = 5\ \frac{m}{s}$

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

AND what is the average force of air resistance if the cat has mass 5.00 kg? $\quad V_0 = 0$

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

$$W = F \cdot d$$

$$418 = F_f(20)$$

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

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

$10\ GJ = 10 \times 10^9\ J \qquad v = 3\ \frac{km}{s} \qquad m = 1500\ kg \qquad eff = ?$

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

↳ 'useful'

↳ total energy

used.