Introduction to Physical Science

Power

Presented by Robert Wagner

Power

- Scientific definition of power
  - The rate at which work is done
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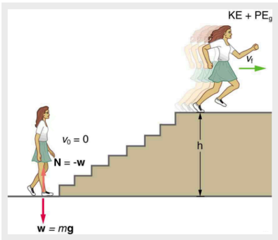
- SI units power: watt
  - 1 Watt = 1 Joule/second

Figure 7.22 This powerful rocket on the Space Shuttle *Endeavor* did work and consumed energy at a very high rate. (credit: NASA)

Example

- Calculate the power output for a 60.0 kg woman who runs up a 3.00 m flight of stairs in 3.50 s, starting from rest and having a final speed of 2.00 m/s.
  - Draw a sketch
  - Identify known values
  - Identify equation
  - Enter values in the equation and solve



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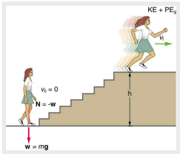

$m = 60.0\,kg\ ;\ h = 3.00\,m\ ;\ t = 3.50\,s\ ;\ v_f = 2.00\,m/s$

$$W = KE + PE = KE_f + PE_g$$

$$W = \frac{1}{2}mv_f^2 + mgh$$

$$P = \frac{W}{t} = \frac{\frac{1}{2}mv_f^2 + mgh}{t}$$

$$P = \frac{0.5(60.0\,kg)(2.00\,m/s)^2 + (60.0\,kg)(9.80\,m/s^2)(3.00\,m)}{3.50\,s}$$

$$P = 538W$$

Power Examples

- Sunlight
  -
  - Only a small amount of this is retained by Earth
- Power => Energy transfer
  - Some energy is lost as thermal energy
- Coal power plant
  - Consumes 2500 megawatts to produce 1000 megawatts of electricity
  - 1500 megawatts lost as heat

Power Examples

Object or Phenomenon	Power in Watts
Supernova (at peak)	5×10^{37}
Milky Way galaxy	10^{37}
Crab Nebula pulsar	10^{28}
The Sun	4×10^{26}
Volcanic eruption (maximum)	4×10^{15}
Lightning bolt	2×10^{12}
Nuclear power plant (total electric and heat transfer)	3×10^{9}
Aircraft carrier (total useful and heat transfer)	10^{8}
Dragster (total useful and heat transfer)	2×10^{6}
Car (total useful and heat transfer)	8×10^{4}
Football player (total useful and heat transfer)	5×10^{3}
Clothes dryer	4×10^{3}
Person at rest (all heat transfer)	100
Typical incandescent light bulb (total useful and heat transfer)	60
Heart, person at rest (total useful and heat transfer)	8
Electric clock	3
Pocket calculator	10^{-3}

Power and Energy Consumption

- Power consumption rate
  -
  - E is the energy supplied by the electric company
  - Energy used is expressed in units of kilowatt-hours (   )

Example

- What is the cost of running a 0.200 kW computer 6.00 h per day if the cost of electricity is $0.120 per kW-h
  - Draw a sketch
  - Identify known values
  - Identify equation
  - Enter values in the equation and solve

$P = 0.200\ kW\ ;\ t = (6.00\ h/d)(30\ d)\ ;$

$rate = \$0.120\ per\ kW \cdot hr$

$E = Pt$

$E = (0.200\ kW)(6.00\ h/d)(30.0\ d)$

$E = 36.0\ kW \cdot h$

$Cost = E \cdot r$

$Cost = (36.0\ kW \cdot h)(\$0.120\ per\ kW \cdot h)$

$Cost = \$4.32\ per\ month$

Summary

- Power is defined to be the rate at which work is done
- Energy conversion to power cannot be 100% efficient
- The amount of energy used is generally expressed in kilowatt-hours