Power

Unit: Energy, Work & Power

MA Curriculum Frameworks (2016): N/A
MA Curriculum Frameworks (2006): 2.4

Mastery Objective(s): (Students will be able to...)
- Calculate power as a rate of energy consumption.

Success Criteria:
- Variables are correctly identified and substituted correctly into the appropriate equations.
- Algebra is correct and rounding to appropriate number of significant figures is reasonable.

Tier 2 Vocabulary: power

Language Objectives:
- Explain the difference between total energy and power.

Notes:

power: a measure of the rate at which energy is applied or work is done. Power is calculated by dividing work (or energy) by time.

\[ P = \frac{W}{t} = \frac{\Delta K}{t} = \frac{\Delta U}{t} \]

Power is a scalar quantity and is measured in Watts (W).

\[ 1 \text{ W} = 1 \frac{\text{J}}{\text{s}} = 1 \frac{\text{N} \cdot \text{m}}{\text{s}} = 1 \frac{\text{kg} \cdot \text{m}^2}{\text{s}^3} \]

Note that utility companies measure energy in kilowatt-hours. This is because

\[ P = \frac{W}{t} \]

which means energy = \( W = Pt \).

Because 1 kW = 1000 W and 1 h = 3600 s, this means

\[ 1 \text{ kWh} = (1000 \text{ W})(3600 \text{ s}) = 3600000 \text{ J} \]

Because \( W = Fd \), this means \( P = \frac{Fd}{t} = F \left( \frac{d}{t} \right) = Fv \)

Use this space for summary and/or additional notes:
Solving Power Problems

Many power problems require you to calculate the amount of work done or the change in energy, which you should recall is:

\[ W = F \cdot d \]  
force caused by linear displacement

\[ \Delta K_i = \frac{1}{2} m (v_i^2 - v_o^2) \]  
change in energy caused by a change in velocity

\[ \Delta U_g = m g \Delta h \]  
change in energy caused by a change in height

Once you have the work or energy, you can plug it in for either \( W, \Delta K \) or \( \Delta U \), use the appropriate parts of the formula:

\[ P = \frac{W}{t} = \frac{\Delta K + \Delta U}{t} = Fv \]

and solve for the missing variable.

Sample Problems:

Q: What is the power output of an engine that pulls with a force of 500 N over a distance of 100 m in 25 s?

A: \[ W = Fd = (500)(100) = 50000 \text{ J} \]
\[ P = \frac{W}{t} = \frac{50000}{25} = 2000 \text{ W} \]

Q: A 60 W incandescent light bulb is powered by a generator that is powered by a falling 1.0 kg mass on a rope. Assuming the generator is 100% efficient (i.e., no energy is lost when the generator converts its motion to electricity), how far must the mass fall in order to power the bulb at full brightness for 1.0 minute?

A: \[ P = \frac{\Delta U_g}{t} = \frac{mg \Delta h}{t} \]
\[ 60 = \frac{(1)(10) \Delta h}{60} \]
\[ 3600 = 10 \Delta h \]
\[ \Delta h = \frac{3600}{10} = 360 \text{ m} \]

Note that 360 m is approximately the height of the Empire State Building. This is why changing from incandescent light bulbs to more efficient compact fluorescent or LED bulbs can make a significant difference in energy consumption!