Section 5.4: Efficiency, Energy Sources, and Energy Conservation

Tutorial 1 Practice, page 243

1. Given: E_{in} = 5200 J; m = 50.0 kg; h = 4.0 m; g = 9.8 N/kg
Required: efficiency
Analysis: $E_g = mgh$; $E_{out} = E_g$;

$$\text{efficiency} = \frac{E_{out}}{E_{in}} \times 100\ \%$$

Solution:

$$\begin{aligned} E_g &= mgh \\ &= (50.0\ \cancel{\text{kg}})\left(9.8\ \frac{\text{N}}{\cancel{\text{kg}}}\right)(4.0\ \text{m}) \\ E_g &= 1960\ \text{J} \\ E_{out} &= 1960\ \text{J} \end{aligned}$$

$$\begin{aligned} \text{efficiency} &= \frac{E_{out}}{E_{in}} \times 100\ \% \\ &= \frac{1960\ \cancel{\text{J}}}{5200\ \cancel{\text{J}}} \times 100\ \% \\ &= 37.69\ \% \\ \text{efficiency} &= 38\ \% \end{aligned}$$

Statement: The efficiency of the forklift is 38 %.

2. Given: m = 1250 kg; h = 1.8 m; F_a = 5500 N; Δd = 12.6 m
Required: E_{out}; E_{in}; efficiency
Analysis: $E_g = mgh$; $E_{out} = E_g$; $W = F\Delta d$; $W = E_{in}$;

$$\text{efficiency} = \frac{E_{out}}{E_{in}} \times 100\ \%$$

(a) E_g, amount of useful energy produced:
Solution:

$$\begin{aligned} E_g &= mgh \\ &= (1250\ \cancel{\text{kg}})\left(9.8\ \frac{\text{N}}{\cancel{\text{kg}}}\right)(1.8\ \text{m}) \\ &= 22\ 050\ \text{N•m} \\ &= 22\ 050\ \text{J} \\ E_g &= 22\ \text{kJ} \end{aligned}$$

Statement: The amount of useful energy produced is 22 kJ.

(b) E_{in}, amount of energy used to pull the car from the ditch:
Solution:

$$\begin{aligned} W &= F\Delta d \\ &= (5500\ \text{N})(12.6\ \text{m}) \\ &= 69\ 300\ \text{N•m} \\ &= 69\ 300\ \text{J} \\ W &= 69\ \text{kJ} \\ E_{in} &= 69\ \text{kJ} \end{aligned}$$

Statement: The amount of energy used to pull the car from the ditch is 69 kJ.

(c) The percent efficiency:
Solution:

$$\begin{aligned} \text{efficiency} &= \frac{E_{out}}{E_{in}} \times 100\ \% \\ &= \frac{22\ 050\ \cancel{\text{J}}}{69\ 300\ \cancel{\text{J}}} \times 100\ \% \\ &= 31.82\ \% \\ \text{efficiency} &= 32\ \% \end{aligned}$$

Statement: The efficiency is 32 %. In any process, there is always some energy lost to friction, which is converted to thermal energy. Therefore, the percent efficiency is less than 100 %.

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1. Given: m = 54 kg; v_i = 0 m/s; v_f = 11 m/s; efficiency = 85 %
Required: E_{in}
Analysis: $E_{out} = \Delta E_k$; $E_k = \frac{1}{2}mv^2$;

$$\text{efficiency} = \frac{E_{out}}{E_{in}} \times 100\ \%$$

Solution:

$$\begin{aligned} E_{out} &= \Delta E_k \\ &= E_{kf} - E_{ki} \\ &= \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \\ &= \frac{1}{2}(54\ \text{kg})(11\ \text{m/s})^2 - 0 \\ &= 3267\ \frac{\text{kg•m}^2}{\text{s}^2} \\ E_{out} &= 3267\ \text{J} \end{aligned}$$

$$\text{efficiency} = \frac{E_{out}}{E_{in}} \times 100\ \%$$

$$E_{in} = \frac{E_{out} \times 100\ \%}{\text{efficiency}}$$

$$= \frac{3267\ \text{J} \times 100\ \%}{85\ \%}$$

$$= 3843.5\ \text{J}$$

$$E_{in} = 3800\ \text{J}$$

Statement: The athlete provided an energy of 3800 J.

2. (a) The efficiency of the skier:

Given: $v_i = 0$ m/s; $h_i = 65$ m; $v_f = 23$ m/s; $h_f = 0$ m; $g = 9.8$ N/kg

Required: efficiency

Analysis: $E_{in} = E_g$; $E_{out} = \Delta E_k$; $E_g = mgh$;

$E_k = \frac{1}{2}mv^2$; $\text{efficiency} = \frac{E_{out}}{E_{in}} \times 100\ \%$

Solution:

$$\text{efficiency} = \frac{E_{out}}{E_{in}} \times 100\ \%$$

$$= \frac{E_k}{E_g} \times 100\ \%$$

$$= \frac{\frac{1}{2}\cancel{m}v_f^2}{\cancel{m}gh} \times 100\ \%$$

$$= \frac{v_f^2}{2gh} \times 100\ \%$$

$$= \frac{(23\ \text{m/s})^2 \times 100\ \%}{2(9.8\ \text{N/kg})(65\ \text{m})}$$

$$= 41.52\ \%$$

$$\text{efficiency} = 42\ \%$$

Statement: The efficiency of the skier is 42 %.

(b) Both the kinetic energy and gravitational energy are proportional to the mass, so the mass of the skier can be divided out. Therefore, the mass of the skier travelling down the slope does not affect the efficiency of the skis.

3. Given: $E_{in} = 65$ J (from the golf club); efficiency = 20 %; $m = 46$ g = 0.046 kg

Required: v_i

Analysis: $E_k = \frac{1}{2}mv_i^2$; $E_{out} = E_k$;

$$\text{efficiency} = \frac{E_{out}}{E_{in}} \times 100\ \%$$

Solution:

$$\text{efficiency} = \frac{E_{out}}{E_{in}} \times 100\ \%$$

$$E_{out} = \frac{\text{efficiency} \times E_{in}}{100\ \%}$$

$$= \frac{20\ \% \times 65\ \text{J}}{100\ \%}$$

$$E_{out} = 13\ \text{J}$$

$$E_k = \frac{1}{2}mv_i^2$$

$$v_i = \sqrt{\frac{2E_k}{m}}$$

$$= \sqrt{\frac{2E_{out}}{m}}$$

$$= \sqrt{\frac{2\ (13\ \text{J})}{0.046\ \text{kg}}}$$

$$= 23.77\ \text{m/s}$$

$$v_i = 24\ \text{m/s}$$

Statement: The initial speed of the ball after being struck is 24 m/s.

4. Answers may vary. Sample answers:

(a) Some advantages of non-renewable energy resources are that they are relatively inexpensive, easy to access, easy to store, and easy to transport. Some disadvantages are that they will run out eventually and they contribute to pollution, the greenhouse effect, and acid rain.

(b) Some advantages of renewable energy resources are that they last forever and have low emissions and pollutants. Some disadvantages are the high costs for start-up and maintenance and that the energy they provide is not consistent.

5.

	Nuclear power plants	**Hydroelectric power plants**
efficiency	30 % to 40 %	80 %
method of generating electricity	thermal energy produced by nuclear reaction heats water and creates steam to turn turbines and generators	falling or moving water turns turbines and generators
energy transformations	nuclear energy is converted to electrical energy	kinetic energy (moving water) is converted to electrical energy
environmental impact	produces radioactive waste; entirely safe method of disposing of spent nuclear fuel unknown at present	damming rivers may flood land and disrupt ecosystems

6. Answers may vary. Sample answer:
Fossil fuels should not be considered a renewable energy source because the time span needed to generate the fuels from the decaying matter is millions of years. This is well beyond the lifespan of our current civilization, so these fuels cannot be renewed through natural processes in time for our current generation to benefit from them.
7. Passive solar design is used strictly for heating and cooling purposes. The radiant energy from the Sun is converted to thermal energy, which can be used to heat spaces. Some designs place deciduous trees on the side of the building that gets the most sunlight. In the winter, when deciduous trees lose their leaves, the Sun's energy enters the building and heats the interior spaces. In the summer, when the trees have their leaves, the leaves shade the interior spaces from sunlight so that they remain cooler.
Photovoltaic cells, or solar cells, use light-sensitive materials to convert the Sun's radiant energy directly to electrical energy. The solar cells create an electric current when the Sun shines on them. This electric current can be used immediately for lighting and running appliances, or the solar cells can be connected to batteries to store the energy for use during the night or on cloudy days.

