$$m = \frac{E}{c^2}$$
$$= \frac{5.3\times10^{10}\text{ J}}{(3.00\times10^{8}\text{ m/s})^2}$$
$$= 5.9 \times 10^{-7}\text{ kg}$$

NOTE: A grain of sand may have a mass approximately $2.0\,0 \times 10^{-6}$ kg. $\therefore$ 5.9×10^{-7} kg is very small amount of gasoline, approximately one-third of the volume of a grain of sand.

NOTE: in order to obtain 5.3×10^{10} J of energy by chemical means, you would burn approximately 1500 L of gasoline in your car.

$$\frac{16{,}000\text{ km}}{10.6\text{ km/L}} \approx 1500\text{ L}$$

Lesson 4–Relativistic Addition of Velocities

1. $$u = \frac{v+u'}{1+\frac{vu'}{c^2}}$$
$$= \frac{0.80c+0.75c}{1+\frac{(0.80c)(0.75c)}{c^2}}$$
$$= 0.97c \text{ away}$$

2. $$u = \frac{v+u'}{1+\frac{vu'}{c^2}}$$
$$= \frac{-0.80c+0.75c}{1+\frac{(-0.80c)(0.75c)}{c^2}}$$
$$= -0.13c \text{ or } 0.13c \text{ toward}$$

NOTE: The negative sign indicates that the object is moving toward the stationary observer.

3. $$u = \frac{v+u'}{1+\frac{vu'}{c^2}}$$
$$= \frac{0.75c+0.60c}{1+\frac{(0.75c)(0.60c)}{c^2}}$$
$$= 0.93c \text{ toward}$$

4. $$u = \frac{v+u'}{1+\frac{vu'}{c^2}}$$
$$= \frac{0.80c+(-c)}{1+\frac{(0.80c)(-c)}{c^2}}$$
$$= c$$

5. $$u = \frac{v+u'}{1+\frac{vu'}{c^2}}$$
$$= \frac{0.80c+c}{1+\frac{(0.80c)(c)}{c^2}}$$
$$= c$$

NOTE: In problems #4 and #5, you will note that it does not matter if the vehicle is travelling toward or away from the stationary observer. The velocity of light is the same.

6. $$u = \frac{v+u'}{1+\frac{vu'}{c^2}}$$
$$= \frac{2.5\times10^{8}\text{ m/s}+2.0\times10^{8}\text{ m/s}}{1+\frac{(2.5\times10^{8}\text{ m/s})(2.0\times10^{8}\text{ m/s})}{(3.00\times10^{8}\text{ m/s})^2}}$$
$$= 2.9 \times 10^{8}\text{ m/s away}$$

7. $$u = \frac{v+u'}{1+\frac{vu'}{c^2}}$$
$$= \frac{2.5\text{ m/s}+6.0\text{ m/s}}{1+\frac{(2.5\text{ m/s})(6.0\text{ m/s})}{(3.0\times10^{8}\text{ m/s})^2}}$$
$$= 8.0\text{ m/s away}$$

NOTE: This is the same answer that you would get if you just added the two velocity vectors together as you added vectors earlier in this course. Relativistic effects are only observable at very high velocities.