SPACE COMMUNICATIONS AND NAVIGATION (SCaN)
CLASSROOM WORKSHEET

National Aeronautics and Space Administration

MONEY MA$$-EMATICS

Ratios and Percentages with Laser Communications

Answer Key

Example:
Convert [student's] mass to kilograms. *(This will vary, but an average 6th-grader has a mass between 28 and 42 kg.)*

Calculate cost to orbit. *(This will vary, but expect answers between ~$120,000 and ~$250,000)*

Example: $41\ kg * \frac{\$4{,}990}{1\ kg} = \$204{,}590$

1. What is the mass of a spacecraft with a launch cost of $2,205,580 weigh?

$$\$2{,}205{,}580 * \frac{1\ kg}{\$4{,}990} = \mathbf{442\ kg}$$

2. What is the mass of the laser telescope?

$$mass_{radio} * \frac{25}{100} = mass_{telescope} \rightarrow 76\ kg * \frac{25}{100} = \mathbf{19\ kg}$$

3. By what percentage have we reduced the mass?

$$mass_{new} = mass_{old} - mass_{radio} + mass_{telescope}$$

$$mass_{new} = 442\ kg - 76\ kg + 19\ kg = 385\ kg$$

$$percentage\ of\ old\ mass = \frac{new\ mass}{old\ mass} = \frac{385\ kg}{442\ kg} = 87\%$$

$$mass\ percentage\ reduction: 100\% - 87\% = \mathbf{13\%}$$

If students are confused by the different masses, suggest they organize the values that are being tracked (and the numbers that go with them):

- payload mass without any communications system
- payload mass with radio system
- payload mass with laser system

4. How many dollars in launch costs might we save with the laser system?

   There are a few ways to tackle this problem, but it is simplest to recalculate launch costs with the new mass:

$$cost_{new} = 385\ kg * \frac{\$4{,}990}{1\ kg} = \$1{,}921{,}150$$

$$savings_{mass\_reduction} = cost_{old} - cost_{new} = \$2{,}205{,}580 - \$1{,}921{,}150 = \mathbf{\$284{,}430}$$

5. By what percentage have we reduced cost?

$$percentage\ of\ old\ cost = \frac{new\ cost}{old\ cost} = \frac{\$1{,}921{,}150}{\$2{,}205{,}580} = \mathbf{87\%}$$

$$cost\ percentage\ reduction = 100\% - 87\% = \mathbf{13\%}\ (or\ 12.9\%)$$

   We see the same percentage reduction in **cost** as we do in **mass** because the mass and cost are **directly proportional** to one another.

6. The mass reduction of 13% is greater than the threshold of 10%, so we **can** use the smaller NMBS-2K! However, a mass reduction of 13% is **not enough** to fit on a COMET-180.

7. What are the total cost savings?

$$savings_{total} = savings_{mass\_reduction} + savings_{rocket} + savings_{transport}$$

$$savings_{rocket} = rocketcost_{CLNSWP\text{-}7} - rocketcost_{NMBS2K} = \$207{,}000$$

$$savings_{transport} = transportcost_{CLNSWP\text{-}7} - transportcost_{NMBS2K} = \$22{,}180$$

$$savings_{total} = \$284{,}430 + \$207{,}000 + \$22{,}180 = \mathbf{\$513{,}610}$$