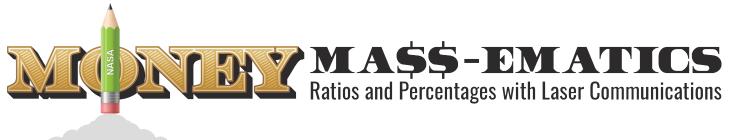
SPACE COMMUNICATIONS AND NAVIGATION (SCaN) CLASSROOM WORKSHEET





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

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

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

2. What is the mass of the laser telescope?

$$\operatorname{mass}_{\operatorname{radio}} * \frac{25}{100} = \operatorname{mass}_{\operatorname{telescope}} \longrightarrow 76 \text{ kg} * \frac{25}{100} = 19 \text{ kg}$$

3. By what percentage have we reduced the mass?

$$\begin{aligned} \text{mass}_{\text{new}} &= \text{mass}_{\text{old}} \text{ - mass}_{\text{radio}} + \text{mass}_{\text{telescope}} \\ \text{mass}_{\text{new}} &= 442 \text{ kg} \text{ - } 76 \text{ kg} + 19 \text{ kg} = 385 \text{ kg} \\ \text{percentage of old mass} &= \frac{\text{new mass}}{\text{old mass}} = \frac{385 \text{ kg}}{442 \text{ kg}} = 87\% \\ \text{mass percentage reduction: } 100\% \text{ - } 87\% = \textbf{13}\% \end{aligned}$$

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:

$$\begin{aligned} & \cos t_{\text{new}} = 385 \text{ kg} * \frac{\$4,990}{1 \text{ kg}} = \$1,921,150 \\ & \text{savings}_{\text{mass}} \text{ reduction} = \cos t_{\text{old}} \text{ - } \cos t_{\text{new}} = \$2,205,580 \text{ - } \$1,921,150 = \$284,430 \end{aligned}$$

5. By what percentage have we reduced cost?

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

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

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?

$$\begin{aligned} & \text{savings}_{\text{total}} = \text{savings}_{\text{mass_reduction}} + \text{savings}_{\text{rocket}} + \text{savings}_{\text{transport}} \\ & \text{savings}_{\text{rocket}} = \text{rocketcost}_{\text{CLNSWP-7}} \text{-} \text{rocketcost}_{\text{NMBS2K}} = \$207,000 \\ & \text{savings}_{\text{transport}} = \text{transportcost}_{\text{CLNSWP-7}} \text{-} \text{transportcost}_{\text{NMBS2K}} = \$22,180 \\ & \text{savings}_{\text{total}} = \$284,430 + \$207,000 + \$22,180 = \$513,610 \end{aligned}$$