

Part A

Which of the following is *not* considered crucial for life to exist on some world?

ANSWER:

- ☒ an atmosphere
- ☐ a source of nutrients
- ☐ a liquid, such as liquid water
- ☐ a source of energy that can be used by life

Correct

An atmosphere is not necessarily required for life. For example, life might exist in Europa's ocean, but Europa has no atmosphere.

Problem 24.54

Suppose there are 17,000 civilizations broadcasting radio signals in the Milky Way Galaxy right now.

Part A

On average, how many stars would we have to search before we would expect to hear a signal? Assume there are 500 billion stars in the galaxy.

Express your answer using two significant figures.

ANSWER:

$$N_A = 2.9 \times 10^7 \text{ stars}$$

Correct**Part B**

How would the answer change if there were only 120 civilizations instead of 17,000?

Express your answer using two significant figures.

ANSWER:

$$N_B = 4.2 \times 10^9 \text{ stars}$$

Correct

Problem 24.56

Suppose we have a spaceship about the size of a typical ocean cruise ship today, which means it has a mass of about 90 million kilograms, and we want to accelerate it to a speed of 9% of the speed of light.

Part A

How much energy would be required? (*Hint:* You can find the answer simply by calculating the kinetic energy of the ship when it reaches its cruising speed; because 9% of the speed of light is still small compared to the speed of light, you can use this formula: kinetic energy = $\frac{1}{2} \times m \times v^2$.)

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$$E = 3.3 \times 10^{22} \text{ J}$$

Correct

Part B

How does your answer compare to total world energy use at present, which is about 5×10^{22} joules per year?

Express your answer as a percentage using two significant figures.

ANSWER:

$$\frac{E_{\text{spaceship}}}{E_{\text{world energy use}}} = 66 \%$$

Correct

Part C

The typical cost of energy today is roughly 5 cents per 1 million joules. Using this price, how much would it cost to generate the energy needed by this spaceship?

Express your answer in dollars to two significant figures.

ANSWER:

$$\text{cost} = 1.6 \times 10^{15} \$$$

Correct

Problem S3.52

Draw a spacetime diagram on which the time axis is marked in years and the space axis is marked in light-years. Assume you are floating weightlessly and therefore consider yourself at rest. Assume the direction to the right of you as the positive direction, and that time is measured from the moment when you meet the person.

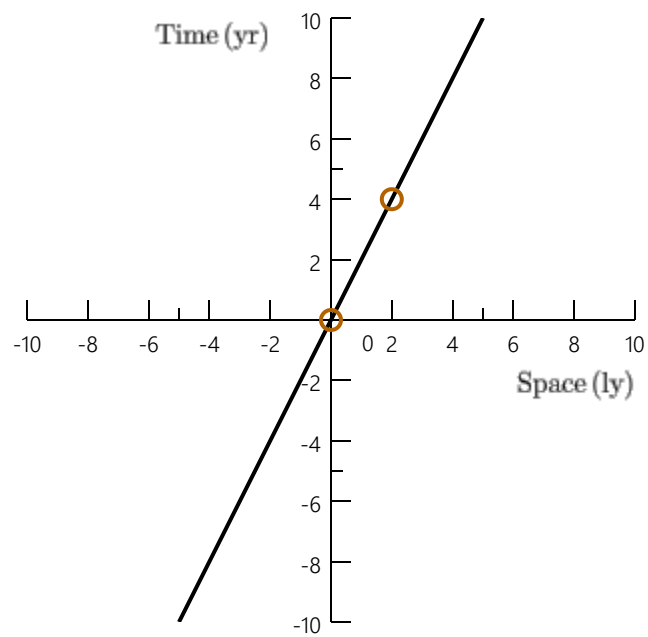
Part A

Draw a worldline for Sebastian, who is moving to your right at $0.5c$.

ANSWER:



No elements selected



Select the elements from the list and add them to the canvas setting the appropriate attributes. Press **TAB** to get to the main menu.

Correct

Part B

Draw a worldline for Michaela, who is moving to your left at $0.7c$.

ANSWER: