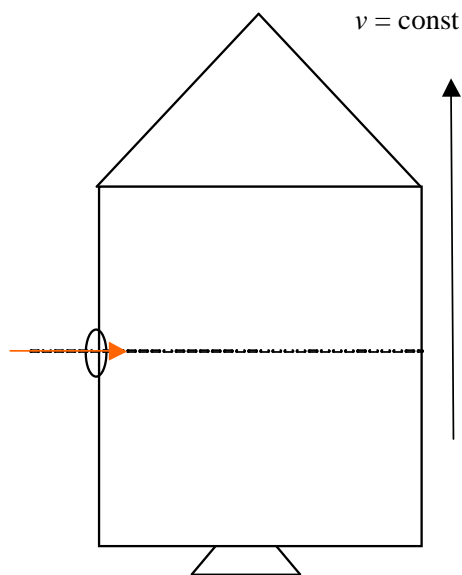


**Support Worksheet – Option H, Worksheet 2**

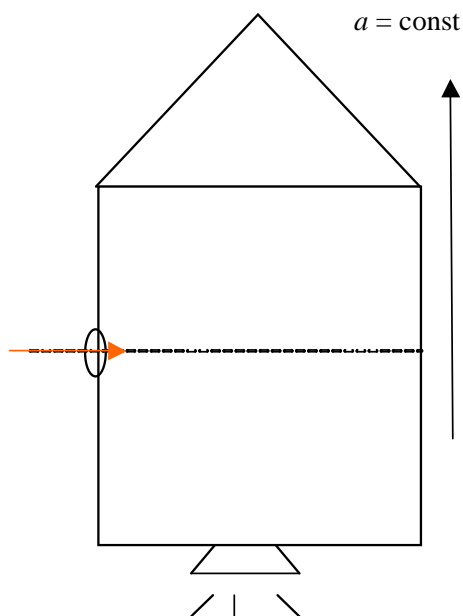
- 1 Describe what is meant by the **twin paradox**. [2]
- 2 State how the twin paradox is resolved. [2]
- 3 Outline the Hafele–Keating experiment. [3]
- 4 A rocket moves with speed $0.40c$ relative to the ground. Gases leave the rocket with a speed of $0.40c$ relative to the rocket. Determine the speed of the gases relative to the ground. [2]
- 5 Two rockets are both moving to the right. The rocket ahead has speed $0.75c$ relative to the ground and the trailing rocket has speed $0.60c$. Determine the speed of the trailing rocket relative to the rocket ahead. [2]
- 6 A proton of rest mass $938 \text{ MeV } c^{-2}$ is accelerated from rest by a potential difference of $8.20 \times 10^8 \text{ V}$.
 - a Determine the total energy of the accelerated proton. [2]
 - b Draw a sketch graph to show the variation with time of the speed of a proton that is accelerated from rest by a constant electric field. [2]
 - c Explain the graph you drew in **b**. [2]
- 7 The lifetime of a muon is $2.2 \times 10^{-6} \text{ s}$ according to an observer at rest with respect to the muon. A muon moves with speed $0.80c$ relative to a lab. Calculate, according to an observer in the lab, the distance travelled by the muon during its lifetime. [2]
- 8 A proton (rest mass $938 \text{ MeV } c^{-2}$) has a total energy of 1890 MeV . Calculate the momentum of the proton. [2]
- 9 Particle X has rest mass m and speed $0.80c$ relative to a lab. Particle Y has rest mass $2m$ and speed $0.40c$ relative to the same lab. Calculate the ratio of momenta $\frac{p_X}{p_Y}$ according to an observer in the lab. [2]
- 10 State the **principle of equivalence**. [1]
- 11 State two physical consequences of the equivalence principle. [2]

- 12 The diagram shows a rocket moving at constant velocity in outer space.



A ray of light, initially moving parallel to the rocket floor, enters the rocket from a glass window. Show the path of the ray according to an observer

- a inside the rocket. [1]
- b outside the rocket. [1]
- 13 The diagram shows a rocket moving with constant acceleration in outer space.



A ray of light, initially moving parallel to the rocket floor, enters the rocket from a glass window moving initially parallel to the floor of the rocket. Show the path of the ray according to an observer

- a inside the rocket [1]
- b outside the rocket. [1]