Support Worksheet – Option H, Worksheet 1

1 Describe what is meant by a **frame of reference**. [1]

2 State what is meant by an **inertial** frame of reference. [1]

3 Two inertial frames of reference, X and Y, have their origins coincide when clocks in both frames are set to zero. Frame Y moves along the common positive *x*-axis with speed 20 m s^{-1} relative to frame X. Lightning strikes at the point which has coordinate, in the X frame, $x = 15$ m when the clocks show $t = 2.0$ s.

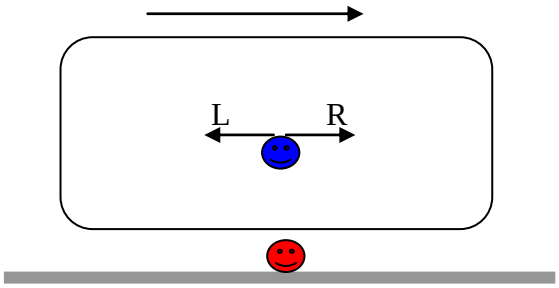
a Using a Galilean transformation determine the coordinates of the event 'lightning strikes' in the Y frame. [2]

b Explain why the use of a Galilean transformation is permissible in this case. [1]

4 State the two postulates of special relativity. [2]

5 State the condition for two events that are simultaneous for one observer to be also simultaneous for another observer who moves relative to the first observer. [1]

6 Two light rays leave the middle of a box towards the left and right walls of the box. The light rays are emitted at the same time according to an observer inside the box. The box moves to the right relative to the ground.

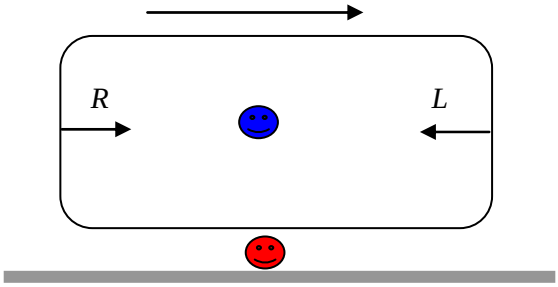


Explain why, according to the observer on the ground:

a the light rays are emitted at the same time. [1]

b Ray L reaches the wall before ray R. [3]

7 Two light rays leave the walls of a box towards the middle of the box. The light rays are emitted at the same time according to an observer in the middle of the box. The box moves to the right relative to the ground.



Determine, explaining your work, which ray was emitted first according to the observer on the ground. [3]

8 Define the term **proper time interval**. [1]

9 Derive the time dilation formula $\Delta t = \dfrac{\Delta\tau}{\sqrt{1-\dfrac{v^2}{c^2}}}$ where $\Delta\tau$ is a proper time interval. [3]

10 Calculate the Lorentz gamma factor, γ, for a speed of $0.980c$. [1]

11 Calculate the speed corresponding to a gamma factor of $\gamma = 3.25$. [2]

12 A pendulum is attached to the ceiling of a box. The box moves with speed $0.75c$ relative to the ground. The period of a pendulum is 1.20 s according to an observer inside the box. Determine the period of the pendulum according to an observer on the ground. [3]

13 An observer inside a rocket passing by the Earth observes that the half-life of a radioactive sample in a lab on Earth is 5.4×10^{-8} s. The speed of the rocket is $0.92c$ relative to the lab. Calculate the half-life of the sample according to observers in the lab. [3]

14 Define **proper length**. [1]

15 A rocket of proper length 120 m travels with speed $0.90c$ relative to the ground. Determine the length of the rocket according to

a an observer inside the rocket [1]

b an observer on the ground. [2]

16 Two rockets each of proper length 60 m are approaching each other. The speed of each rocket relative to the ground is 0.60c. The speed of one rocket relative to the other is 0.88c. Calculate the length of one of the rockets as measured by an observer

a on the ground. [2]

b in the other rocket. [2]

17 The distance to a star, according to observers on Earth, is 4.2 ly. A rocket moving at $0.82c$ relative to the Earth leaves Earth towards the star. Calculate the duration of the trip to the star according to the rocket clocks. [2]