Higher Special Relativity Questions

1. a) State what each of the quantities are in the **Time Dilation Equation** below.

$$t' = \frac{t}{\sqrt{1 - \left(\frac{v^2}{c^2}\right)}}$$

b) The **Lorentz Factor** often used in the study of Special relativity is given as

$$\gamma = \frac{1}{\sqrt{1 - \left(\frac{v^2}{c^2}\right)}}$$

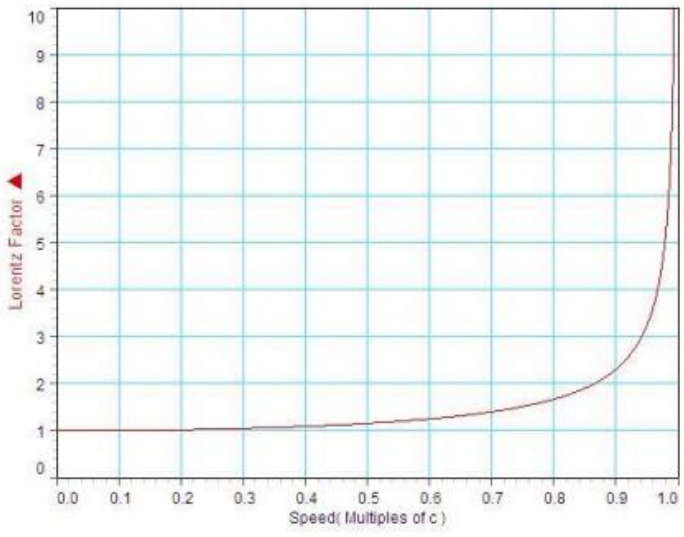
State the equation obtained when the Lorentz factor is substituted into the Time Dilation Equation.

c) Which quantity is always **greater t' or t**?

2. **Calculate** the unknown quantities in the table below.

Dilated Time	**Proper Time**	**Speed of the Object (ms^{-1})**
(a)	16 hours	1.80×10^8
8.5ms	**(b)**	2.35×10^8
12 minutes	10 minutes	**(c)**

3. A graph of **Lorentz Factor versus Speed of light** is shown below.



Explain in detail what this graph shows.

4. a) An aeroplane is travelling at altitude above Larbert at a speed of **240ms^{-1}**.

The pilot measures the journey as taking **50 minutes**.

How long did the journey take when measured by an observer in Larbert?

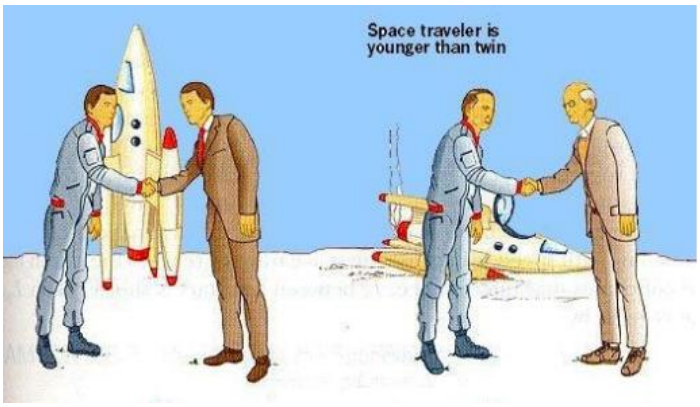
b) A rocket is travelling at altitude above Larbert at a speed of **2.4 x10^{8}ms^{-1}**.

The astronaut on the rocket measures the journey taking **50minutes**.

How long did the journey take when measured by an observer in Larbert?

c) Compare and contrast the answers found in a) and b).

5. The Twin Paradox describes how one of the twins on a space mission for a given time travelling near the speed of light, will age less than the other twin on Earth.



a) **Explain** how this phenomena is possible.

b) A spaceship travelling at **2.8 x 10^{8}ms^{-1}** leaves Earth in May 2000 and returns in May 2016. **How many years** will the astronaut have aged in this time?

6. The lifetime of a star is **8 billion years** measured by an observer at rest with respect to the star.

The star is moving away from the Earth with a speed of **0.85c**.

Calculate the lifetime of the star according to the observer on Earth.

7. A rocket passes Hadrian's Wall as it passes over Earth.

An Astronaut in the rocket measures the time taken to travel over Hadrian's Wall to be **6 x 10^{-4}s**.

An observer on Earth measures the time taken to travel over Hadrian's Wall to be **8 x10^{-4}s**.

Calculate the speed of the rocket relative to the Earth.

8. A scientist in a laboratory measures the time taken for a nuclear reaction to occur in an atom.

When the atom is travelling at **$2.2 \times 10^{8} ms^{-1}$** the reaction takes **$4 \times 10^{-4} s$**.

Calculate the time taken for the reaction to occur when the atom is at rest.

9. a) State what each of the quantities are in the **Length Contraction Equation** below.

$$l' = l\sqrt{1 - \frac{v^2}{c^2}}$$

b) The **Lorentz Factor** often used in the study of **Special Relativity** is given as

$$\gamma = \frac{1}{\sqrt{1 - \left(\frac{v^2}{c^2}\right)}}$$

State the equation obtained when the Lorentz factor is substituted into the Length Contraction Equation.

c) Which quantity is always **greater l' or l**?

10. **Calculate** the unknown quantities in the table below.

Contracted Length	**Proper Length**	**Speed of the Object (ms^{-1})**
(a)	40cm	1.90×10^{8}
800m	**(b)**	2.55×10^{8}
500mm	650mm	**(c)**

11. A rocket is travelling at **0.60c** relative to a space station.

Astronauts on the rocket measure the space station to be **750m long**.

Calculate the length of the space station measured by a member of the station crew.

12. A rocket of length **50m** was measured at rest on Earth.

The rocket passes Earth with a constant speed of **$2.1 \times 10^8 ms^{-1}$**.

Calculate the length of the rocket when it passes Earth and is measured by an observer that is stationary on Earth.

13. The length of a large football stadium is **200m**. A passenger in a high speed plane measures the length of the stadium to be **185m** when it passes by.

Calculate the speed the plane was flying relative to the stadium when the measurement was made.

14. A car has a length measured of **3.2m** when viewed from a spaceship travelling at **$2.0 \times 10^8 ms^{-1}$**.

Calculate the length of the car when measured at rest on Earth.

15. **Proxima Centauri** which is the nearest star to Earth is **4.3 light years** away.

A spacecraft of length **100m** is sent from Earth to Proxima Centauri and the distance measured on the spacecraft is **3.8 light years**.

Calculate or find:

a) **Speed of the spacecraft** relative to Earth.

b) **Time taken** in seconds for the spacecraft to reach Proxima Centauri as measured by a **stationary observer on Earth**.

c) **Time taken** in seconds for the spacecraft to reach Proxima Centauri as measured by a **clock on the spacecraft**.