

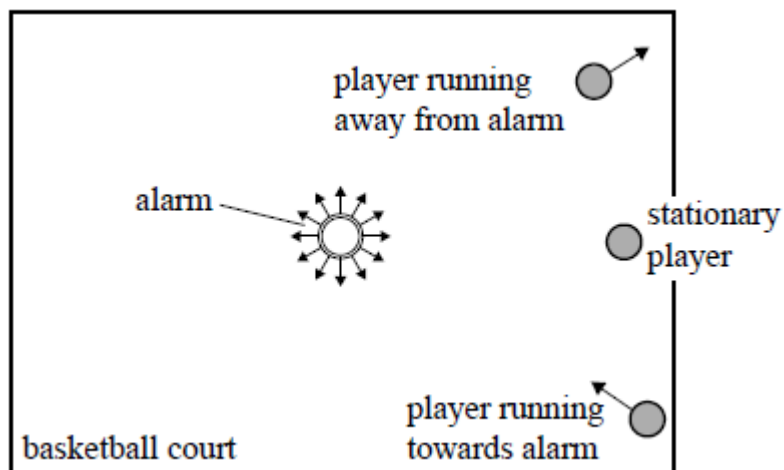
Name \_\_\_\_\_

Total Marks: /55

Answer all questions to 3 significant figures.

**Question 1**

An alarm is sounding in the centre of a large indoor basketball court. A stationary player measures the speed of sound as  $335 \text{ ms}^{-1}$ . A player runs directly towards the alarm (at  $5 \text{ ms}^{-1}$ ) and another runs directly away from the alarm (also at  $5 \text{ ms}^{-1}$ ). As they run they both measure the speed of sound using a small portable device. The situation is shown in the diagram below.

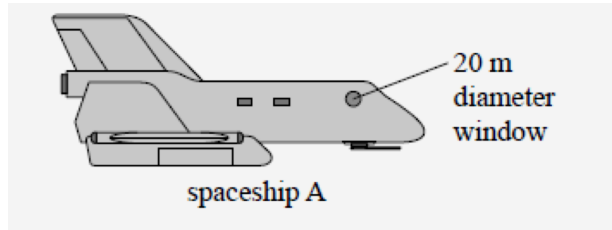


What is the speed of sound as measured by **(2 marks)**

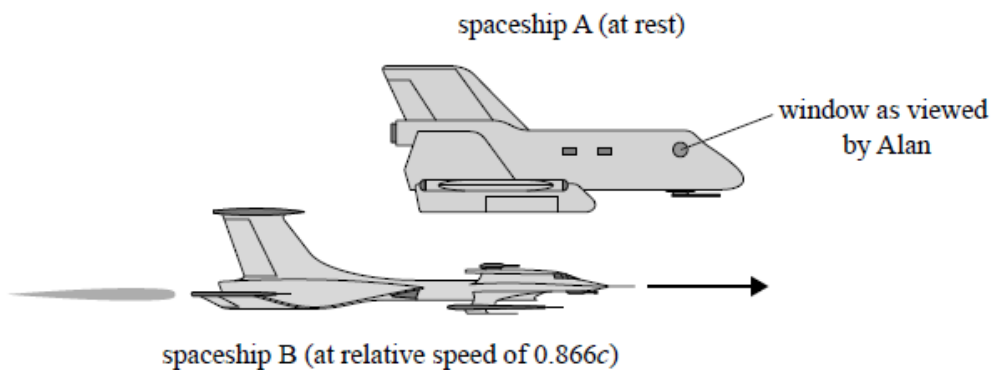
The player running towards the alarm	The player running away from the alarm
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Question 2

Spaceship **A** has a circular window in its side. Alan, a crew member of spaceship **A**, measures the diameter of the window as 20 m. The diagram below shows spaceship **A** at rest.



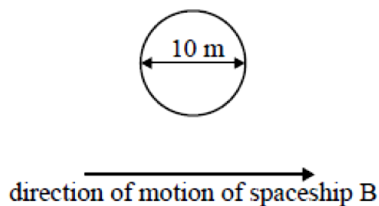
Ivy is a crew member of spaceship **B**. She measures the dimensions of the window as spaceship **B** moves past spaceship **A** at a speed of  $0.866c$ .



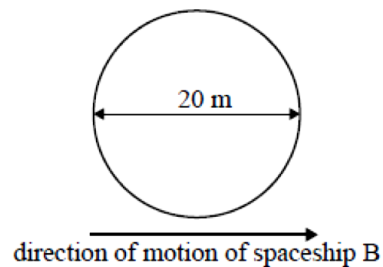
a) Which of the following diagrams best shows the dimensions of the circular window on spaceship **A** as measured by Ivy on spaceship **B**?

(2 marks)

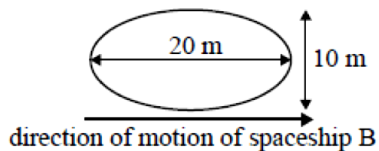
A.



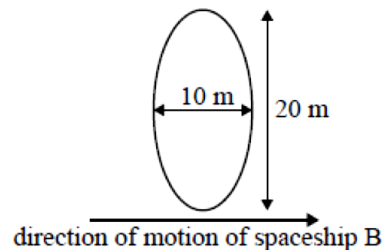
B.



C.



D.



b) Calculate the actual length of the window as seen by Ivy. **(3 marks)**

c) Both Alan and Ivy observe a quasar (distant star). When it is observed, it is at a distance of  $2.5 \times 10^{25}$  km from them and is travelling away from Alan at a speed of  $0.16c$ .

Both Alan and Ivy measure the speed of the light emitted from the quasar. What value would each expect to measure for the speed of light? Explain the reason for your answer. **(2 marks)**

### Question 3

A metre rule is thrown like a spear at a speed of  $0.72c$ . How long does the rule appear to be when seen by a person at rest? **(3 marks)**

**Question 4**

An astronaut moving in a spaceship at  $0.95c$  relative to the Earth measures the time taken for a ball to bounce from the floor to the ceiling of her spacecraft as  $0.66$  seconds. An observer (at rest) watches the spaceship pass by her. According to this observer, how long will it take for the ball to bounce from the floor to the ceiling?

**(3 marks)**

**Question 5**

Suppose that a proton was able to move at  $99.5\%$  of the speed of light. What **relativistic mass** will this proton appear to have when observed by a stationary observer?

**(4 marks)**

**Question 6**

Use the information in your Formulae and Data Sheet to answer the following:

a) If a  $\pi$ -meson has a charge of +1, what combination of quarks could make up a  $\pi$ -meson? **(1 mark)**

b) What combination of quarks could make up the baryon known as an anti-neutron? **(1 mark)**

c) Complete the following table: **(3 marks)**

Combination of Quarks	Overall Charge	Meson or Baryon
Up, down, strange		
Down, anti-up		
Up, anti-strange		

**Question 7**

When a muon meets an anti-muon, both are annihilated and a photon of energy  $3.45 \times 10^{-11}$  J is formed.

What is the mass of a single muon? **(3 marks)**

**Question 8**

- a) Which one of the following l particles is not classified as a **lepton**? Circle your answer. **(1 mark)**

- A: neutrino**
- B: neutron**
- C: electron**
- D: anti-neutrino**

- b) Why are leptons described as being “fundamental particles” whereas hadrons are not? **(2 marks)**

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**Question 9**

In the **STANDARD MODEL of MATTER**, it is assumed that there are 4 fundamental forces found in nature.

Complete the following table. **(3 marks)**

<b>Name of force</b>	<b>What does it act upon?</b>	<b>Name of mediating particle</b>
Strong Force		
Electromagnetic Force		
Weak Force		
Gravitational Force		

## Question 10

Why is it not possible (under the assumptions of Einstein's Theory) for a particle with mass to reach the speed of light? **(4 marks)**

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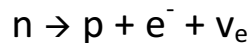
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## Question 11

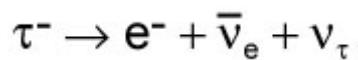
Use conservation of charge, lepton number and baryon number to prove or disprove the possibility of the following interactions. **Show your reasoning.**

- a) A neutron transmutes into a proton, an electron and an electron-neutrino



**(3 marks)**

- b) A tau lepton decays into an electron, an electron-anti-neutrino and a tau neutrino.



**(3 marks)**

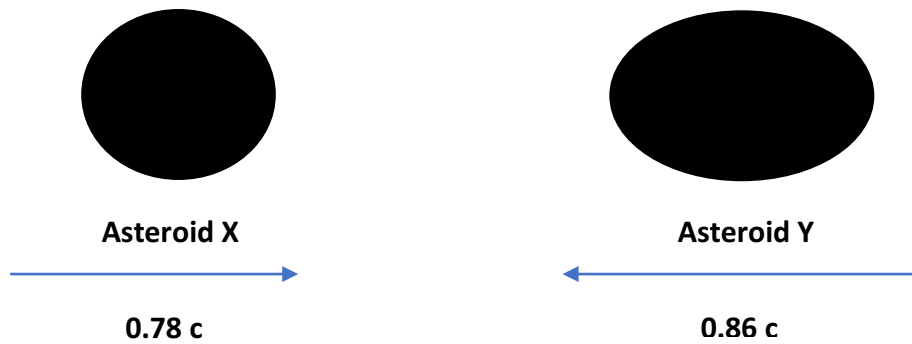
- c) State for the above interactions, which of the fundamental forces was involved.

**(2 marks)**

**Question 12**

Two asteroids are on a course to narrowly miss, but fly by one another. Asteroid **X** is travelling at  $0.78c$  and Asteroid **Y** is travelling at  $0.86c$ .

Marvin is catching a ride on Asteroid **X**. How fast will Marvin observe Asteroid **Y** travelling as it passes him? **(3 marks)**

**Question 13**

For the following statements, state which fundamental force is responsible for the interaction:

**(3 marks)**

Friction	
Nuclear bonding	
Planetary orbits	



**Question 14**

Explain, giving reasons, which of the fundamental forces act on the protons within your body.

**(4 marks)**

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