2001 HIGHER SCHOOL CERTIFICATE EXAMINATION

# Physics

Centre Number

## Section I (continued)

Student Number

**Part B – 60 marks**
**Attempt Questions 16–26**
**Allow about 1 hour and 45 minutes for this part**

Answer the questions in the spaces provided.

Show all relevant working in questions involving calculations.

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**Marks**

**Question 16** (4 marks)

Muons are very short-lived particles that are created when energetic protons collide with each other. A beam of muons can be produced by very-high-energy particle accelerators.

The high-speed muons produced for an experiment by the Fermilab accelerator are measured to have a lifetime of 5.0 microseconds. When these muons are brought to rest, their lifetime is measured to be 2.2 microseconds.

(a) Name the effect demonstrated by these observations of the lifetimes of the muons. **1**

time dilation

(b) Calculate the velocity of the muons as they leave the accelerator. **3**

$t_v = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}$ $\quad 5 = \frac{2.2}{\sqrt{1-\frac{v^2}{c^2}}}$

$\sqrt{1-\frac{v^2}{c^2}} = \frac{2.2}{5}$

$1-\frac{v^2}{c^2} = \left(\frac{2.2}{5}\right)^2$

$c^2 - \left(\frac{2.2}{5}\right)^2 c^2 = v^2$

$v = \sqrt{c^2 - c^2\left(\frac{2.2}{5}\right)^2}$

$= c\sqrt{1-\left(\frac{2.2}{5}\right)^2}$

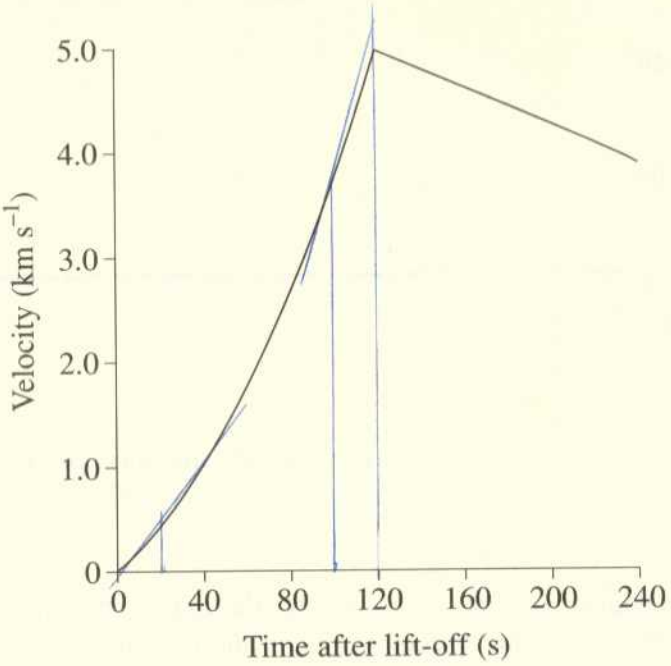
$= c\sqrt{\frac{504}{625}}$

$= \frac{\sqrt{504}}{25}\, c \text{ ms}^{-1}$

Marks

**Question 17** (6 marks)

A rocket was launched vertically to probe the upper atmosphere. The vertical velocity of the rocket as a function of time is shown in the graph.




(a) Using either words or calculations, compare the acceleration of the rocket at $t = 20$ s with its acceleration at $t = 100$ s. **2**

Since acceleration is the rate of change of velocity, then by looking at the gradient of the target at $t = 20$ and $t = 100$, we see that the gradient is steeper for $t = 100$. Therefore the acceleration is greater at $t = 100$s than $t = 20$s.

(b) Account for the shape of the graph over the range of time shown. **4**

When it is first launched, there is non-uniform acceleration as the rocket gathers speed from its fuel combustion. Up until $t = 120$s, the acceleration was non-uniform, hence the curve in the graph. After $t = 120$s the rocket decelerated constantly as illustrated by the straight line which suggest a constant negative gradient. The graph only goes up to $t = 240$'s and assumptions can't be correctly made after this line without more info.