

2001 HIGHER SCHOOL CERTIFICATE EXAMINATION
 Physics

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Centre Number

Section I (continued)

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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.

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

$v \rightarrow v = 0, t = 2.2 \text{ microseconds}$

$v \text{ approaches } c, t = 5.0 \text{ microseconds}$

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

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

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

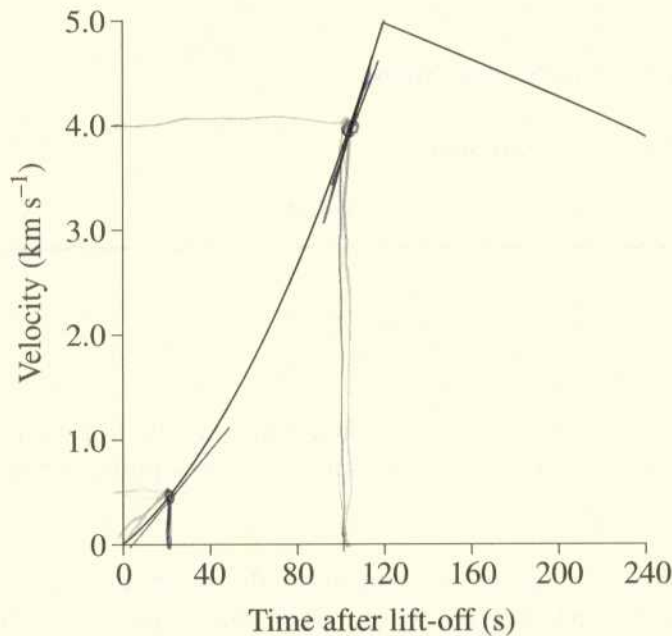
$$2.2 \left(1 - \frac{v^2}{c^2}\right) = 5 \qquad -0.022v^2 = 0.028c^2$$

$$2.2(1 - v) = 5c \qquad -v = 1.27c$$

~~$0.022v^2 = 2.2v = 1.5 \times 10^9$~~
 ~~$-2.2v = 5c = 1.49 \times 10^9$~~
 ~~$v = 2.2 \times 10^9$~~

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

the acceleration at $t = 20$ is not as great as the acceleration at $t = 100$. From the graph, the tangent at $t = 20$ is not as steep as point $t = 100$.

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

the acceleration is constantly increasing until the velocity is reached for the desired orbit. At $t = 120$ the ~~engine~~ rocket engines break off and the probe is sent into orbit, the acceleration decreases, ~~or~~ decreasing the velocity making the graph change from $t = 120$, the velocity continues to decrease until ~~acceleration~~ ^{becomes} acceleration equal zero, and the probe is moving under centripetal ¹⁴ force around the earth