PART III

This part carries 32% of the total examination marks.

You should attempt **TWO** *questions from this part,* **either** *Question 17* **or** *Question 18* *and* **either** *Question 19* **or** *Question 20. Questions are equally weighted, but note that about one-third of the marks for each question are awarded for good problem-solving technique, with Preparation, Working and Checking stages.*

Each question in this part **must** *be answered in a separate single-question answer book.*

EITHER **Question 17**

A gun shot is fired from a distance of 33 m in front of a defence wall, with initial speed of 40 m s^{-1} at an angle of 70° from the horizontal (Figure 4). It just clears the top edge of the wall. How high is the wall? Is a defender, standing on the wall 3 m away from the edge, likely to be hit?

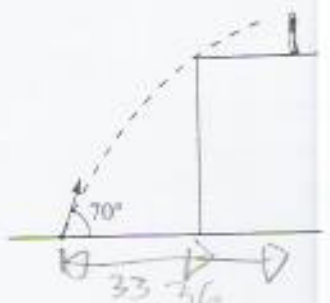

Figure 4 *(not to scale)*

OR **Question 18**

A very long string is aligned along the x-axis. One end of the string moves along the y-axis with simple harmonic motion described by the equation

$$y = y_{max} \sin 3.0t$$

where y is in mm and t is in seconds. As a result of the disturbance, a transverse wave propagates along the string with speed 0.20 m s^{-1} and negligible damping. A point 1.2 m further along the string has a displacement of 8.0 mm at time t = 10 s. Write down in terms of y_{max}, x and t the displacement equation for this travelling wave, and hence calculate the amplitude of the travelling wave.

AND

EITHER **Question 19**

A proton is travelling horizontally, when it enters a uniform vertical magnetic field of magnitude 0.6 T. Seen from above, the particle executes clockwise circular orbits of radius 0.4 m, but it really moves in a helical path because it has a downward component of acceleration due to gravity. Estimate the number of nearly circular orbits it makes while falling through a height of 2 m. Does the magnetic field point vertically upwards or downwards?

OR **Question 20**

A particle of mass $m = 1.0 \times 10^{-27}$ kg is restricted to the x-axis, and has total energy E = 2.0 eV. For positive values of x, the potential energy of the particle has the constant value V = 3.0 eV, while for negative values of x, the potential energy of the particle is equal to zero.

For positive values of x, the wavefunction of the particle takes the form

$$\psi(x) = Ae^{-kx}$$

where A and k are constants.

(a) Verify that this wavefunction is a possible solution of Schrödinger's equation

$$\frac{d^2\psi}{dx^2} + \frac{2m}{\hbar^2}(E - V)\psi = 0$$

in the region $x > 0$, and find the value of k.

(b) If $A = 3.0 \times 10^5$ m$^{-1/2}$, what is the probability that the particle will be found in the small region of the x-axis between 1.0×10^{-11} m and 1.01×10^{-11} m?

[END OF QUESTION PAPER]