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**

An Eskimo standing on firm ground at the edge of a frozen lake throws a pelt of mass 2.0 kg with a speed of 8.0 m s^{-1} at an angle of 30° above the horizontal. The pelt lands in a sledge of mass 20 kg which is initially stationary on the ice of the lake. After this collision, the sledge moves off over the ice in a straight line away from the Eskimo. If the coefficient of sliding friction between the sledge and the ice is 0.02, how far from the *Eskimo* does the sledge come to rest? (You may ignore air resistance.)

OR **Question 18**

Bungee jumping is a sport in which a person jumps from a tall bridge with one end of an elastic rope attached securely to his ankles and the other end attached securely to the bridge. The first part of the motion, while the rope is slack, is a vertical fall under gravity. Once the rope becomes taut it exerts an upward force on the jumper, who then undergoes an oscillatory vertical motion before eventually coming to rest.

Suppose that a jumper of mass 70 kg starts from rest, that the rope attached to his ankles has a natural length of 50.0 m, and that, when the jumper reaches his lowest point, the length of the rope is 55.0 m. You may treat the jumper as a particle of mass m and assume that the rope obeys Hooke's law with force constant k. Use the conservation of energy to find mg/k, and hence calculate the length l_e of the rope when the jumper has finally come to rest. The jumper reaches his maximum speed when the rope has length l_e during his initial descent. What is this maximum speed?

(You should neglect the effects of air resistance throughout.)

AND

EITHER **Question 19**

An electron passes through a region where the magnetic field is uniform, the electric field is initially zero and the gravitational field negligible. From the viewpoint of a fixed observer, the electron is observed to travel in a vertical plane, clockwise round a circular orbit of radius $r = 1.00$ cm with period $T = 1.0 \times 10^{-9}$ s. The observer's line of sight is perpendicular to the plane of the orbit. A uniform electric field is switched on at the moment when the electron is travelling vertically downwards. This has the effect of cancelling the influence of the magnetic field so that the electron flies off at a tangent, moving downwards with constant speed in a straight line. Determine the magnitudes and directions of the magnetic and electric fields.

OR **Question 20**

Light from transitions between the 3p and 2s states in atomic hydrogen passes through a narrow slit and by means of a lens is formed into a parallel beam. This beam falls normally on a diffraction grating, with adjacent slits separated by a distance D. As a result, a diffraction pattern is formed on a screen on the far side of the grating.

When the light beam is replaced by an electron beam and the diffraction grating is replaced by one suitable for use with electrons, with adjacent slits separated by $0.001D$, it is found that an identical diffraction pattern is obtained for electrons accelerated from rest through a potential difference of ΔV. Determine the value of ΔV.

[END OF QUESTION PAPER]