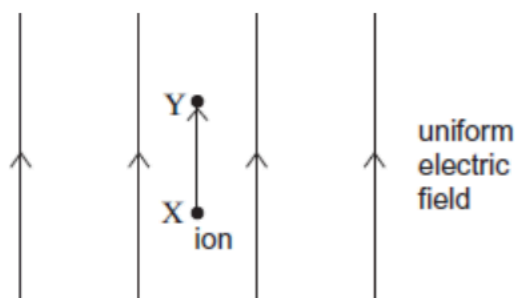


1

A uniform electric field of electric field strength  $E$  is aligned so it is vertical. An ion moves vertically through a small distance  $\Delta d$  from point X to point Y in the field.

There is a uniform gravitational field of field strength  $g$  throughout the region.



Which line, **A** to **D**, in the table correctly gives the gravitational potential difference, and the electric potential difference, between X and Y?

|          | Gravitational potential difference | Electric potential difference |
|----------|------------------------------------|-------------------------------|
| <b>A</b> | $g\Delta d$                        | $E\Delta d$                   |
| <b>B</b> | $g\Delta d$                        | $\frac{E}{\Delta d}$          |
| <b>C</b> | $\frac{g}{\Delta d}$               | $E\Delta d$                   |
| <b>D</b> | $\frac{g}{\Delta d}$               | $\frac{E}{\Delta d}$          |

(Total 1 mark)

2

Two protons, each of mass  $m$  and charge  $e$ , are a distance  $d$  apart. Which one of the

following expressions correctly gives the ratio  $\left( \frac{\text{electrostatic force}}{\text{gravitational force}} \right)$  for the forces acting between them?

**A**  $\frac{4\pi\epsilon_0 e^2}{Gm^2}$

**B**  $\frac{Ge^2}{4\pi\epsilon_0 m^2}$

**C**  $\frac{e^2 m^2}{4\pi\epsilon_0 G}$

**D**  $\frac{e^2}{4\pi\epsilon_0 Gm^2}$

(Total 1 mark)

3

Both gravitational and electric field strengths can be described by similar equations written in the form

$$a = \frac{bc}{d^2}.$$

- (a) Complete the following table by writing down the names of the corresponding quantities, together with their SI units, for the two types of field.

| symbol | <i>gravitational field</i>   |         | <i>electrical field</i>    |                   |
|--------|------------------------------|---------|----------------------------|-------------------|
|        | quantity                     | SI unit | quantity                   | SI unit           |
| a      | gravitational field strength |         |                            |                   |
| b      |                              |         | $\frac{1}{4\pi\epsilon_0}$ | m F <sup>-1</sup> |
| c      |                              |         |                            |                   |
| d      |                              |         |                            |                   |

(4)

- (b) Two isolated charged objects, A and B, are arranged so that the gravitational force between them is equal and opposite to the electric force between them.
- (i) The separation of A and B is doubled without changing their charges or masses. State and explain the effect, if any, that this will have on the resultant force between them.
- \_\_\_\_\_
- \_\_\_\_\_
- (ii) At the original separation, the mass of A is doubled, whilst the charge on A and the mass of B remain as they were initially. What would have to happen to the charge on B to keep the resultant force zero?
- \_\_\_\_\_
- \_\_\_\_\_

(3)

(Total 7 marks)

**4**

Which line, **A** to **D**, correctly describes the trajectory of charged particles which enter, at right angles, (a) a uniform electric field, and (b) a uniform magnetic field?

|          | (a) uniform electric field | (b) uniform magnetic field |
|----------|----------------------------|----------------------------|
| <b>A</b> | circular                   | circular                   |
| <b>B</b> | circular                   | parabolic                  |
| <b>C</b> | parabolic                  | circular                   |
| <b>D</b> | parabolic                  | parabolic                  |

(Total 1 mark)

## Mark schemes

**1** A

[1]

**2** D

[1]

**3** (a)

|                               |                                |                                 |                                           |            |
|-------------------------------|--------------------------------|---------------------------------|-------------------------------------------|------------|
| _____                         | $\text{N kg}^{-1}$             | electric field strength         | $\text{N C}^{-1}$<br>or $\text{V m}^{-1}$ | <b>(1)</b> |
| gravitational constant        | $\text{N m}^2 \text{ kg}^{-2}$ | _____                           | _____                                     | <b>(1)</b> |
| mass                          | kg                             | charge                          | C                                         | <b>(1)</b> |
| distance (from mass to point) | m                              | distance (from charge to point) | m                                         | <b>(1)</b> |

(4)

(b) (i) none **(1)**

both  $F_E$  and  $F_G \propto \frac{1}{r^2}$  (hence both reduced to  $\frac{1}{4}$  [affected equally] **(1)**)

(ii) charge on B must be doubled **(1)**

(3)

[7]

**4** C

[1]