

- 1 (a) Define *gravitational potential* at a point.

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[1]

- (b) The gravitational potential  $\phi$  at distance  $r$  from point mass  $M$  is given by the expression

$$\phi = -\frac{GM}{r}$$

where  $G$  is the gravitational constant.

Explain the significance of the negative sign in this expression.

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[2]

- (c) A spherical planet may be assumed to be an isolated point mass with its mass concentrated at its centre. A small mass  $m$  is moving near to, and normal to, the surface of the planet. The mass moves away from the planet through a short distance  $h$ .

State and explain why the change in gravitational potential energy  $\Delta E_P$  of the mass is given by the expression

$$\Delta E_P = mgh$$

where  $g$  is the acceleration of free fall.

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[4]

- (d) The planet in (c) has mass  $M$  and diameter  $6.8 \times 10^3$  km. The product  $GM$  for this planet is  $4.3 \times 10^{13}$  N m $^2$  kg $^{-1}$ .

A rock, initially at rest a long distance from the planet, accelerates towards the planet. Assuming that the planet has negligible atmosphere, calculate the speed of the rock as it hits the surface of the planet.

speed = ..... ms $^{-1}$  [3]