(d) The students now decide to use their value for g to estimate the mass of the Earth.

(i) Using Newton's universal law of gravitation, $F = \frac{GMm}{r^2}$, and $F = ma$, show that:

$$M_E = \frac{gR^2}{G}$$ [1]

Where M_E = mass of the Earth
R = Radius of the Earth (6.38×10^6m ± 2%)
G = Gravitational constant $(6.6743 \pm 0.0007) \times 10^{-11}$ N m^2 kg^{-2}

- $mg = \frac{GMm}{r^2}$ ***and convincing manipulation*** *(1)*

(ii) Use the above equation, and your value for g to estimate the mass of the Earth, M_E. [1]

- *Mass calculated correctly (e.c.f.) and expressed in kg (1)*

(iii) Calculate the total **percentage** uncertainty in your answer to *(d)*(ii). [3]

- *% uncertainty in R^2 given as 2 × 2% [=4%]*
  [can be awarded by implication if the final answer is correct]
- *Comment that % uncertainty in G is irrelevant [or very small]*
- *Total % uncertainty calculated correctly from 4% + % uncertainty in g [from (c)(ii)] (1)*

(iv) Hence determine the absolute uncertainty in the mass of the Earth. [2]

- *Absolute uncertainty calculated correctly and expressed to 1 s.f. (1)*
  [From (c)(i) × (c)(ii) / 100]
- *mass quoted with a precision consistent with uncertainty (1)*