InkPhysics

ANSWER BOOK

Comparing electric and gravitational fields

Electric fields · Year 13

AQA 3.7.1, 3.7.3.1 · OCR A 6.2.2

10 questions · 30 marks

NAVY EDITION

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SECTION A · Warm-up

A1 Gravity: $F = GMm/r^2$, depending on the two masses. Electrostatics: $F = kQ_1Q_2/r^2$, depending on the two charges. Both fall off as the inverse square of separation. [2]

A2 Gravitational: $g = GM/r^2$. Electric: $E = kQ/r^2$. [2]

A3 Gravity acts only as an attraction (there is one kind of mass), whereas the electric force can be attractive or repulsive because charge comes in two kinds. [2]

SECTION B · Standard

B1 Gravitational: $V = -GM/r$ (always negative). Electric: $V = kQ/r$ (positive for a positive charge, negative for a negative charge). Gravitational potential is always negative; electric potential can take either sign. [3]

B2 The r^2 cancels: ratio $= ke^2/(Gm_pm_e) = (8.99 \times 10^9 \times (1.60 \times 10^{-19})^2)/(6.67 \times 10^{-11} \times 1.67 \times 10^{-27} \times 9.11 \times 10^{-31}) \approx 2.27 \times 10^{39}$. [4]

B3 Large bodies are electrically almost neutral: their equal positive and negative charges cancel, so there is little net electric force. Mass, however, only adds up, so the gravitational attraction of huge masses becomes dominant on the astronomical scale. [3]

B4 Any two of: both are inverse-square with distance; both have radial fields around a point source; both define a field strength as force per unit mass/charge; both have a potential with its zero taken at infinity; both store energy. [3]

SECTION C · Stretch

C1 $F_{elec} = ke^2/r^2 = (8.99 \times 10^9 \times (1.60 \times 10^{-19})^2)/(1.0 \times 10^{-15})^2 = 230$ N. $F_{grav} = Gm_p^2/r^2 = 1.86 \times 10^{-34}$ N. [4]

C2 Source: mass vs charge. Force law: $F = GMm/r^2$ vs $F = kQ_1Q_2/r^2$ (both inverse-square). Attraction/repulsion: attraction only vs both. Potential: $V = -GM/r$ (always negative) vs $V = kQ/r$ (either sign). [4]

C3 Everyday objects are electrically neutral overall, so their positive and negative charges cancel and produce almost no net electric force. Their mass does not cancel, so the ever-present gravitational attraction (especially of the Earth) is what we feel. [3]