Solutions for Topic 10 – Fields (AHL)

1. \( \frac{3g}{4} \)

2. The acceleration \( a \) of the spacecraft is \( \frac{v-u}{t} = \frac{300}{600} = 0.50 \text{ m s}^{-2} \)
   This is also the gravitational field strength, \( g = 0.50 \text{ N kg}^{-1} \)

3. a) a conductor contains free electrons and insulators do not
   b) electrons must move along the wire and so an electric force must act on them this is provided by the electric field
   c) \( 55 \times 1.6 \times 10^{-19} \)
      \( = 8.8 \times 10^{-18} \text{ N} \)
   d) Similarity:
      both follow an inverse square law
      Differences:
      gravitational force is much weaker than electric force
      electric force can be attractive or repulsive, gravity only attractive
   e) (i) \( 25 \text{ N kg}^{-1} \)
      (ii) \( M = \frac{25 R^2}{G} \)
      \( = \frac{25 \times 7.0^2 \times 10^{14}}{6.7 \times 10^{11}} \)
      \( = 1.8 \times 10^{22} \text{ kg} \)

4. The astronaut and the spacecraft experience the same acceleration

5. a) work done in moving mass from infinity to a point;
   b) (i) accurate read-offs at \(-12.6\) and \(-3.2\)
      or gain in gravitational potential \([12.6 \times 10^6 - 3.2 \times 10^6]\)
      \(9.4 \times 10^6 \times 12 \times 10^6 = 1.13 \pm 0.05 \times 10^5 \text{ MJ} \)
      (ii) use of gradient of graph to determine \( g \)
      values substituted from drawn gradient \( \left( \text{typically} \frac{6.7 \times 10^6}{7 \times 3.3 \times 10^6} \right) \)
      \( = (0.23 \pm 0.3) \text{ N kg}^{-1} \)
   c) \( g \) at surface \( = 4^2 g \) at \( 4R \)
      and \( \frac{3.7}{0.25} = 16.1 \)
      \( = 3.7 \text{ N kg}^{-1} \)
   d) escape speed for Earth > escape speed for Mars
      potential less/more negative at Earth

6. \( F_X = \frac{GM}{d^2} = 90 \text{ N} \)
   \( F_Y = \frac{4GM}{(ad)^2} = \frac{4}{9} F_X = 40 \text{ N} \)