## Solutions

Each answer shows the steps, then the **result**.

**2.1**

- the **gravitational force per unit mass** on a small test mass at that point ($g = F/m$)

**2.2**

- N $kg^{-1}$

**2.3**

- the **direction of the gravitational force** on a (test) mass at that point

**2.4**

- **radial**, pointing **inwards** towards the mass

**3.1 B**

- $g = F/m$, so field strength is **force ÷ mass**
- **A** is force; **C** is $GMm/r^2$ without dividing by $m$; **D** is potential

**3.2**

- $F = 19.6$ N, $m = 2.0$ kg; $g = F/m$

$$g = \frac{19.6\ \text{N}}{2.0\ \text{kg}} = \mathbf{9.8}\ \text{N kg}^{\mathbf{-1}}$$

**3.3**

- a **stronger** gravitational field

**3.4**

(a) **radial** lines pointing inward to the mass

(b) **parallel, equally spaced** lines pointing down towards the surface

**3.5**

(a) the gravitational **force per unit mass** acting on a small test mass placed at that point

(b) the force on the test mass is $F = GMm/x^2$, where $G$ is the gravitational constant

- field strength is the force per unit mass

$$g = \frac{F}{m} = \frac{GM}{x^2}$$

(c) the fields point in **opposite directions**, since each points towards the mass

- $g \propto 1/x^2$, so halving the distance makes the field at Q **four times** the field at P

(d) the curve starts at $(R,\ -g_0)$, since at X's surface the field points back towards X, i.e. negative

- it passes through zero at the midpoint $x = L/2$
- it ends at $(L - R,\ +g_0)$, becoming shallower up to the midpoint and steeper after it

(e) the two spheres are identical and the midpoint is equidistant from both, so their fields there are **equal in magnitude**

- and **opposite in direction**, so as a vector the two cancel to zero
- *(the gravitational potential there is not zero — only the field is)*