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1 **(a)** **(i)** force / area (normal to the force) B1 [1]

(ii) ($p = F/A$ so) units: $\text{kg m s}^{-2}/\text{m}^2 = \text{kg m}^{-1}\text{s}^{-2}$ A1 [1]

allow use of other correct equations:
e.g. ($\Delta p = \rho g \Delta h$ so) $\text{kg m}^{-3}\,\text{m s}^{-2}\,\text{m} = \text{kg m}^{-1}\text{s}^{-2}$
e.g. ($p = W/\Delta V$ so) $\text{kg m s}^{-2}\,\text{m}/\text{m}^3 = \text{kg m}^{-1}\text{s}^{-2}$

(b) units for m: kg, t: s and ρ: kg m^{-3} C1

units of C: $\text{kg}/\text{s}\,(\text{kg m}^{-3}\,\text{kg m}^{-1}\,\text{s}^{-2})^{1/2}$
or
units of C^2: $\text{kg}^2/\text{s}^2\,\text{kg m}^{-3}\,\text{kg m}^{-1}\,\text{s}^{-2}$ C1

units of C: m^2 A1 [3]

2 **(a)** $\Delta E = mg\Delta h$ C1

$= 0.030 \times 9.81 \times (-)0.31$

$= (-)0.091$ J A1 [2]

(b) $E = \frac{1}{2}mv^2$ C1

(initial) $E = \frac{1}{2} \times 0.030 \times 1.3^2$ $(= 0.0254)$ C1

$0.5 \times 0.030 \times v^2 = (0.5 \times 0.030 \times 1.3^2) + (0.030 \times 9.81 \times 0.31)$ so $v = 2.8\,\text{m s}^{-1}$
or
$0.5 \times 0.030 \times v^2 = (0.0254) + (0.091)$ so $v = 2.8\,\text{m s}^{-1}$ A1 [3]

(c) **(i)** $0.096 = 0.030\,(v + 2.8)$ C1

$v = 0.40\,\text{m s}^{-1}$ A1 [2]

(ii) $F = \Delta p/(\Delta)t$ *or* $F = ma$
$= 0.096/20 \times 10^{-3}$ *or* $0.030\,(0.40 + 2.8)/20 \times 10^{-3}$ C1

$= 4.8$ N A1 [2]

(d) <u>kinetic</u> energy (of ball and wall) decreases/changes/not conserved, so inelastic
or
(relative) speed of approach (of ball and wall) not equal to/greater than (relative)
speed of separation, so inelastic. B1 [1]

(e) force = work done / distance moved
$= (0.091 - 0.076)/0.60$ C1

$= 0.025$ N A1 [2]

3 (a) resultant force (in any direction) is zero — B1
resultant moment/torque (about any point) is zero — B1 [2]

(b) (i) force = 33 sin 52° *or* 33 cos 38°
= 26 N — A1 [1]

(ii) 26×0.30 *or* $W \times 0.20$ *or* 12×0.40 — C1

$26 \times 0.30 = (W \times 0.20) + (12 \times 0.40)$ — C1

$W = 15\,\text{N}$ — A1 [3]

(c) (i) $E = \Delta\sigma/\Delta\varepsilon$ *or* $E = \sigma/\varepsilon$ — C1

$\Delta\sigma = 2.0 \times 10^{11} \times 7.5 \times 10^{-4}$
$= 1.5 \times 10^{8}\,\text{Pa}$ — A1 [2]

(ii) $\Delta\sigma = \Delta F/A$ *or* $\sigma = F/A$ — C1

$A = 78/1.5 \times 10^{8}$ $(= 5.2 \times 10^{-7}\,\text{m}^2)$ — C1

$5.2 \times 10^{-7} = \pi d^2/4$

$d = 8.1 \times 10^{-4}\,\text{m}$ — A1 [3]

4 (a) wave incident on/passes by or through an aperture/edge — B1
wave spreads (into geometrical shadow) — B1 [2]

(b) (i) waves (from slits) overlap (at point X) — B1

path difference (from slits to X) is zero/
phase difference (between the two waves) is zero
(so constructive interference gives bright fringe) — B1 [2]

(ii) difference in distances = $\lambda/2 = 580/2$
= 290 nm — A1 [1]

(iii) $\lambda = ax/D$ — C1

$D = [0.41 \times 10^{-3} \times (2 \times 2.0 \times 10^{-3})]/580 \times 10^{-9}$ — C1

= 2.8 m — A1 [3]

(iv) same separation/fringe width/number of fringes
bright fringe(s)/central bright fringe/(fringe at) X less bright
dark fringe(s)/(fringe at) Y/(fringe at) Z brighter
contrast between fringes decreases

Any two of the above four points, 1 mark each — B2 [2]

5 **(a)** <u>total</u>/<u>sum</u> of electromotive forces or e.m.f.s

= <u>total</u>/<u>sum</u> of potential differences or p.d.s   M1

around a loop/(closed) circuit   A1   [2]

  (b) **(i)** (current in battery =) current in A + current in B   *or* $I_A + I_B$ C1

        (I =) 0.14 + 0.26 = 0.40 A   A1   [2]

      (ii) $E = V + Ir$

        6.8 = 6.0 + 0.40r *or*   6.8 = 0.40 (15 + r)   C1

        $r = 2.0\ \Omega$ A1   [2]

     (iii) $R = V/I$ C1

        ratio (= R_A / R_B) = (6.0/0.14)/(6.0/0.26)
                      = 42.9/23.1   *or*   0.26/0.14

                       = 1.9 (1.86)   A1   [2]

     (iv) **1.** $P = EI$ or VI *or* $P = I^2 R$ *or* $P = V^2/R$ C1

           = 6.8 × 0.40   = 0.40^2 × 17   = 6.8^2/17

           = 2.7 W (2.72 W)   A1   [2]

         2. output power = VI
                        = 6.0 × 0.40 (= 2.40 W)   C1

           efficiency = (6.0 × 0.40)/(6.8 × 0.40) = 2.40/2.72
                     = 0.88 or 88% (*allow 0.89 or 89%*)   A1   [2]

6 (a) hadron not a fundamental particle/lepton is fundamental particle
or
hadron made of quarks/lepton not made of quarks
or
strong force/interaction acts on hadrons/does not act on leptons   B1   [1]

(b) (i) $_{1}^{0}e^{(+)}$ or $_{1}^{0}\beta^{(+)}$ B1

$_{0}^{0}\nu_{(e)}$ B1   [2]

(ii) weak (nuclear force / interaction)   B1   [1]

(iii) • mass-energy
• momentum
• proton number
• nucleon number
• charge

Any three of the above quantities, 1 mark each   B3   [3]

(c) (quark structure of proton is) up, up, down or uud   B1

up/u (quark charge) is $(+)\frac{2}{3}(e)$, down/d (quark charge) is $-\frac{1}{3}(e)$ C1

$\frac{2}{3}e + \frac{2}{3}e - \frac{1}{3}e = (+)e$ A1   [3]