M1.(a)

breaking stress	✓
stiffness constant, k	
tensile strain	
tensile stress	
Young modulus	✓

1

(b) (i) elastic limit ✓

only one attempt at the answer is allowed

1

(ii) ($E = 300 \times 10^6 / 4 \times 10^{-2} = 7.5 \times 10^9$)

7.5 (Pa) ✓ allow 7.4 to 7.6 (Pa)

$\times 10^9$ ✓

first mark is for most significant digits ignoring the power of 10. E.g. 7500 gains mark

2

(c) <u>straight line</u> beginning on existing line at a strain of 0.10 and hitting the strain axis at a lower non-zero value ✓

line that ends on the x -axis with strain between 0.045 and 0.055 ✓(only allow if first mark is given)

ie accuracy required ± one division

2

(d) 8.99×10^{-3} (m^3) ✓ condone 1 sig fig

allow 9.00×10^{-3}

1

(e) $0.9872 \times 8.99 \times 10^{-3}$ or = 8.8749×10^{-3} (m^3) ✓

allow CE from 4d

($m = \rho V$)= 2700 × 8.8749 × 10^{-3} = 24 (kg) ✓ (23.962 kg)
allow CE from first part, e.g. if 1.28% was used gives 0.311 kg

V =0.9872 × (d)

m = 2.665 × (d)

1.28% of vol = 1.15 × 10^{-4} m^3

2

[9]

M2.(a) Use of Young Modulus = $\frac{\text{tensile stress}}{\text{tensile strain}}$ ✓

The first mark is for calculating the tensile stress

1

To give tensile stress = 2 × 10^{11} × 3.0 × 10^{-4} = 6.0 × 10^{7} ✓

The second mark is substituting into the tensile force equation

1

Use of tensile stress = $\frac{\text{tensile force}}{\text{cross sectional area}}$

To give tensile force = 6.0 × 10^{7} × 7.5 × 10^{-3} = 4.5 × 10^{5} N ✓

The third mark is for the correct answer

1

(b) Use of strain = extension / original length

To give extension = 3.0 × 10^{-4} × 45 = 1.4 × 10^{-2} m

(1.35 × 10^{-2}) ✓

The first mark is for calculating the extension

1

Use of energy stored = ½ F e

To give

Energy stored = ½ × 4.5 × 10^5 × 1.4 × 10^{-2}

= 3.2 × 10^3 J ✓

(3.04 × 10^3)

The second mark is for the final answer

1

(c) Temperature change = pre-strain / pre-strain per K

= 3.0 × 10^{-4} / 2.5 × 10^{-5} = 12 K✓

The first mark is for the temperature change

1

Temperature = 8°C + 12 = 20 °C ✓

The second mark is for the final answer

1

(d) So that the rail is not always under stress✓

1

as the rail spends little time at the highest temperature✓

Or

To reduce the average stress the rail is under ✓

as zero stress will occur closer to average temperature / the rail will be under compressive / tensile stress at different times✓

1

[9]

M3.(a) 6.5 × 10^{10} Pa ✓

1

(b) kg m^{-1} s^{-2} ✓

1

(c) Direction of movement of particles in transverse wave perpendicular to energy propagation direction ✓

1

Parallel for longitudinal ✓

1

(d) $\rho_1 c_1 = \rho_2 c_2$ ✓

$E = \rho c^2$ or $\rho c = \frac{E}{c}$ seen

1

$\left[\frac{E_1}{c_1} = \frac{E_2}{c_2}\right]$

1

(e) $[\frac{\rho_x}{\rho_y} = \frac{c_y}{c_x}$ and $c_x = 2c_y$]

0.5 ✓

1

(f) speed of the wave in seawater is less than speed of the wave in glass ✓

1

argument to show that $_{water}n_{glass}$

1

so tir could be observed when wave moves from water to glass ✓

1

[10]

M4. C

[1]

M5.(a) P at the end of linear section ✓ **1**

(b) Measure original length and diameter ✓ **1**

Determine gradient of linear section to obtain F / extension ✓ **1**

$$E = \frac{F}{e} \times \frac{length}{\pi\left(\frac{d}{2}\right)^2}$$ ✓ **1**

Alternative:
Convert to stress–strain graph and determine gradient.

(c) Line from A

Parallel to straight section of original

Ending at horizontal axis ✓ **1**

(d) Plastic deformation has produced permanent extension / re-alignment of bonds in material hence intercept non-zero ✓ **1**

Gradient is same because after extension identical forces between bonds ✓ **1**

(e) 0.2% is a strain of 0.002

Stress = $2.0 \times 10^{11} \times 0.002$ = **1**

4×10^{8} ✓

$$Force\left(=\frac{\pi(6\times10^{-3})^2}{4}\times 4\times 10^8\right)✓$$ 1

= 11.3 kN ✓ 1

(f) Maximum force = 11300 N

Weight of mass = 600 x 9.81 = 5886 N ✓ 1

Accelerating force must be less than

11300 – 5886 = 5423 N ✓ 1

$a\ (= F / m$ = 5423 / 600)

= 9.0 m s^{-2} ✓ 1

(g) To lift double the load at the same acceleration, would require double the force, ✓

The first mark is for discussing the effect on the force 1

To produce the same strain either use:

- double the cross sectional area of wire – so the stress stays the same and therefore the strain is the same for the same wire, ✓ 1
- a wire with double the Young modulus – so that double the stress produces the same strain for the same diameter. ✓ 1

The other two are for discussing the two alternative methods of keeping the strain the same

[16]