M1. (a) resultant force zero **(1)**
resultant torque about any point zero **(1)**

2

(b) (i) force due to wire P = 5.0 - 2.0 = 3.0 N **(1)**

(ii) (moments give) $5.0 \times d = 2.0 \times 0.90$ **(1)**
d= 0.36 m **(1)**

3

[5]

M2. (a) (i) horizontal component = 850 × cos 42 **(1)**
= 630 N **(1)** (632 N)

(ii) vertical component = 850 × sin 42 = 570 N **(1)** (569 N)
(if mixed up sin and cos then CE in (ii))

(iii) weight of girder = 2 × 570 = 1100 N **(1)** (1142 N)
(use of 569 N gives weight = 1138 N)
(allow C.E. for value of vertical component in (ii))

4

(b) arrow drawn vertically downwards at centre of girder **(1)**

1

[5]

M3. (a) (i) two from: velocity, acceleration, force etc ✓

1

(ii) two from: speed, distance, mass etc ✓

1

(b) (i) B: drag / air resistance ✓

C: weight ✓

2

(ii) closed triangle (of vectors) ✓

so forces are in **equilibrium / resultant force is zero / forces balance**
(so moving at constant velocity) ✓

2

(c) W = 9500 sin 74 ✓

= 9100 ✓ (9132)

2 sf ✓

3

[9]

M4. (a) (i) (horizontal) force = zero **(1)**

(ii) (vertical) force = 2 × 15 sin 20 **(1)**

= 10(.3) N **(1)**

3

(b) (i) weight (of block) = 10(.3) N **(1)**

(allow C.E. for value from (a) (ii))

(ii) resultant force must be zero **(1)**

with reference to an appropriate law of motion **(1)**

3

[6]

M5. (a) (i) vector has direction **and** a scalar does not **(1)**

(ii) scalar examples; any two e.g. speed, mass, energy, time, power

vector examples; any two e.g. displacement, velocity, acceleration, force or weight

(1)(1)(1) for 4 correct, **(1)(1)** for 3 correct, **(1)** for 2 correct

4

(b) (i) horizontal component (= 2.8 cos 35) = 2.3 (kN) (2293.6) **(1)**

vertical component (= 2.8 sin 35) = 1.6(kN) (1606.0) **(1)**

(ii) power = force × velocity **or** 2.3 kN × 8.3 m s^{-1} **(1)** (ecf from (b) (i))

= 1.9×10^4 (19037 or 19100) **(1)** ecf

W (or J s^{-1}) **(1)** (or 19 W (or kJ s^{-1}))

5

(c) (area of cross–section of cable =) $\pi \times (\frac{1}{2}\ 0.014)^2$ **(1)**

$= 1.5(4) \times 10^{-4}$ (m^2) (1)

stress (=F/A) = $\frac{2800\ \text{N}}{1.54 \times 10^{-4}\ \text{m}^2}$

(allow ecf here if attempt to calculate area) **(1)**

$= 1.8(2) \times 10^7$ **(1)** ecf

Pa (or N m^{-2}) **(1)**

QWC	descriptor	mark range
good-excellent	The candidate provides a comprehensive and coherent description which includes all the necessary measurements in a logical order. The description should show awareness of the need to use a range of standard masses. In addition, the use of the measurements is explained clearly, including an outline of a graphical method to find the mass of the rock sample, or calculation using two or more standard masses and averaging. For 6 marks there must be a description of how to make accurate measurements.	**5-6**
modest-adequate	The candidate's description includes the necessary measurements using one standard mass as well as the rock sample. The description may not be presented in a logical order and they show little consideration in relation to making the measurements accurately. A clear explanation is provided of how to find the mass of the rock sample from their measurements, including correct use of Hooke's law through calculations or inadequate graphical method.	**3-4**
poor-limited	The candidate knows the necessary measurements to be made using a standard mass and the rock sample. The explanation of how to find the mass of the rock sample may be sketchy.	**1-2**

5

[14]

M6. (a) the point (in a body) **(1)**

where the weight (or gravity) of the object appears to act

[or resultant torque zero] **(1)**

2

(b) (i) $P \times 0.90 = 160 \times 0.50$ **(1)**
$P = 89$ N (88.9 N)

(ii) $Q = (160 - 89) = 71$ N **(1)**
(allow C.E. for value of *P* from (i))

3

(c) (minimum) force × 0.10 = 160 × 0.40 **(1)**

force = 640 N **(1)**

2

(d) force is less **(1)**

because distance to pivot is larger **(1)**

smaller force gives large enough moment (1)

3

[10]

M7. (a) product of the force and the **perpendicular distance (1)**
reference to a point/pivot **(1)**

2

(b) (i) since *W* is at a greater distance from A **(1)**
then *W* must be less than *P* if moments are to be equal **(1)**

(ii) *P* must increase **(1)**
since moment of girl's weight increases as she moves from A to B **(1)**
correct statement about how P changes
(e.g. P minimum at A, maximum at B, or P increases in a linear fashion) **(1)**

max 4

[6]

M8. (a) (sum of) clockwise moment**s** (about a point) =(sum of) anticlockwise moment**s (1)**

(for a system) in equilibrium **(1)**

accept balanced not stationary

2

(b) (780 × 0.35 =) 270 (Nm) **(1)** (273)

Nm (1) or newton metre(s) accept Newton metre(s)
(not J, nm or nM, Nms, etc)

2

(c) (b) + (1100 × 0.60) **(1)**

(=) F_A × 1.3 **(1)** (F_A = 660 + 273/1.3 gets both marks)

(= 933/1.3) = 720 (N) **(1)** (717.7 or 715 for use of 930)
ecf (b)

2 sf only (1)
independent mark

4

(d) (780 + 1100 – (c)) = 1200 **(1)** (1162 N)
ecf (c)

1

(e) $\left(F = \frac{P}{v}\right) = \frac{7.5(\times 10^3)}{26}$ **(1)**

must be arranged in this form

= 290 (N) **(1)** (288.46)

2

[11]

M9. (a) (i) weight of container (= mg = 22000 × 9.8(1)) = 2.16 × 10^5 (N) **(1)**

tension (= ¼ *mg*) = (5.39) 5.4 × 10^4 (N) or divide a weight by 4 **(1)**

(ii) moment (= force × distance) = 22000 *g* × 32 **(1)** ecf weight in (a) (i)

= 6.9 or 7.0 × 10^6 **(1)** **N m** or correct base units **(1)** not J, nm, NM

(iii) the counterweight **(1)**

provides a (sufficiently large) anticlockwise moment (about Q)
or moment in opposite direction (to that of the container to
prevent the crane toppling clockwise) **(1)**

or
left hand pillar pulls (down) **(1)**
and provides anticlockwise moment

or
the centre of mass of the crane('s frame and the counterweight)
is between the two pillars **(1)**

which prevents the crane toppling **clockwise**/to right **(1)**

7

(b) (i) (tensile) stress $\left(= \frac{\text{tension}}{\text{csa}}\right) = \frac{5.4 \times 10^4}{3.8 \times 10^{-4}}$ ecf (a) (i) **(1)**

$= 1.4(2) \times 10^8$ **(1)** **Pa** (or N m^{-2}) **(1)**

(ii) extension = $\frac{\text{length} \times \text{stress}}{E}$ or $\frac{FL}{EA}$ **(1)**

$= \frac{25 \times 1.4 \times 10^8}{2.1 \times 10^{11}}$ and (= 1.7×10^{-2} m) = 17 (mm) **(1)**

5

[12]

M10. (a) (moment) force × perpendicular **(1)** distance (from the point) **(1)**

2

(b) (i) the point in a body where the resultant torque is zero [or where the (resultant) force of gravity acts or where the weight acts through] **(1)**

(ii) $F \times 2.5 = 1800 \times 0.35$ **(1)**
$F = 250$ N **(1)** (252 N)

(iii) $F_R = (1800 - 252)$ **(1)**
= 1500 N **(1)** (1548) N
[use of $F = 250$ N gives $F_R = 1550$ N or 1600 N)
(allow C.E. for incorrect value of F from (ii))

5

(c) force must have a horizontal component **(1)**
F (therefore) increases in magnitude **(1)**
and act at an angle (to the vertical) towards the car **(1)**

3
QWC 1

[10]