4. Forces, Density and Pressure

4.2 Equilibrium of forces

Paper 2

Marking Scheme

Q1.

(c)(i)	$1.7 \times 2.0\ (\times 10^{-2})$ **or** $4.5 \times 10^{-2} \times 9.81 \times d$	**C1**
	$1.7 \times 2.0 \times 10^{-2} = 4.5 \times 10^{-2} \times 9.81 \times d$ $d = 7.7 \times 10^{-2}$ m	**A1**
(c)(ii)	clockwise	**B1**

Q2.

(b)(ii)	$W = U + D$	**A1**

Q3.

(b)	resultant force (in any direction) is zero	**B1**
	resultant moment / torque (about any point) is zero	**B1**
(c)(i)	(moment =) $33 \times 0.65 / 2$ **or** $1.5 \times (0.65 - 0.12)$ **or** $T \sin 50° \times (0.65 / 2)$	**C1**
	sum of clockwise moments = sum of anticlockwise moments $33 \times (0.65 / 2) + 1.5 \times (0.65 - 0.12) = T \sin 50° \times (0.65 / 2)$	**C1**
	tension = 46 N	**A1**

Q4.

(a)(ii)	(8.2×0.50) **or** $(W \times 0.60)$ **or** (0.30×0.80) **or** (2.4×1.2)	**C1**
	$(8.2 \times 0.50) = (W \times 0.60) + (0.30 \times 0.80) + (2.4 \times 1.2)$	**C1**
	$W = 1.6$ N	**A1**
(a)(iii)	force $= 4.8 \cos 30°$ $= 4.2$ N	**A1**

Q5.

(b)(i)	(54×0.45) **or** (2.4×0.95) **or** $(T \sin 30° \times 1.3)$	**C1**
	$(54 \times 0.45) = (2.4 \times 0.95) + (T \sin 30° \times 1.3)$	**C1**
	$T = 34$ N	**A1**
(b)(ii)	resultant moment $= (54 \times 0.45) - (2.4 \times 0.95)$ **or** $(34 \sin 30° \times 1.3)$ $= 22$ N m	**A1**

Q6.

(a)(i)	arrow upwards (↑) **and** labelled upthrust / U arrow downwards (↓) **and** labelled weight / W / mg arrow downwards (↓) **and** labelled tension / T *1 mark: One or two correctly labelled arrows* *2 marks: Three correctly labelled arrows*	**B2**

Q7.

(b)(i)	moments about P are: ($F \times 1.10$), (44.0×0.60) and (3.0×2.90) *1 mark for any one correct moment and 2 marks for two correct moments*	**C2**
	($F \times 1.10$) = (44.0×0.60) + (3.0×2.90) F = 32 N	**A1**
(b)(ii)	force = 32 + 44 + 3 = 79 N	**A1**
(c)(ii)	resultant moment = 2.5×2.9 = 7.3 N m **or** resultant moment = $F \times 1.1 - (44 \times 0.6 + 0.5 \times 2.9)$ = 7.3 N m (allow 7.2 N m or 7.4 N m from rounded values of F)	**A1**
	direction: anticlockwise	**A1**

Q8.

(b)(i)	T = 430 sin 11° **or** 430 cos 79°	**C1**
	= 82 N	**A1**

Q9.

(a)	T sin 68° + 32 = 280	**C1**
	T = 270 N	**A1**

Q10.

(b)(ii)	the magnitudes of the three moments about A are (23×0.48), (27×0.56) and ($W \times 0.76$) correct magnitude of any one moment about A	**C1**
	correct magnitudes of any two moments about A	**C1**
	(23×0.48) + ($W \times 0.76$) = 27×0.56 W = 5.4 N	**A1**
(b)(iii)	horizontal component = 45 cos 37° = 36 N	**A1**
(b)(iv)	decrease	**B1**

Q11.

(f)	there is a resultant force (acting on sphere) **or** there is a resultant moment (about P acting on pendulum) (so) not in equilibrium	**B1**

Q12.

(b)	resultant force (in any direction) is zero	**B1**
	resultant torque/moment (about any point) is zero	**B1**
(c)(ii)	(T =) 43 – 28 = 15 (N) **or** (T =) 42.9 – 28 = 14.9 or 15 (N)	**A1**

Q13.

(a)	resultant force (in any direction) is zero	**B1**
	resultant torque/moment (about any point) is zero	**B1**
(b)(i)	**1.** $T \sin 53° = 2.4$ $T = 3.0$ N	**A1**
	2. $F = T \cos 53°$ **or** $F^2 = T^2 - 2.4^2$ $F = 1.8$ N	**A1**

Q14.

(c)(ii)	$(T \times 2.4)$ **or** (4.3×1.2) **or** (4.6×1.8)	**C1**
	$(T \times 2.4) + (4.3 \times 1.2) = (4.6 \times 1.8)$	**C1**
	$T = 1.3$ N	**A1**

Q15.

(a)(iii)	$T = 0.84 - 0.39$ $= 0.45$ N	**A1**

Q16.

(b)	(45×2.9) **or** $(T \times 1.8)$ **or** (59×1.5)	**C1**
	$(45 \times 2.9) = (T \times 1.8) + (59 \times 1.5)$	**C1**
	$T = 23$ N	**A1**

Q17.

(b)(ii)	constant velocity so no resultant force (so in equilibrium)	**B1**

Q18.

(b)(iii)	$54 \sin 35° \times 0.68$ **or** $54 \cos 35° \times 0.68$ **or** $W \times 0.34$	**C1**
	$54 \sin 35° \times 0.68 + 54 \cos 35° \times 0.68 = W \times 0.34$ so $W = 150$ (N)	**A1**
(b)(iv)	total vertical force $= 150 - 31$ $= 120$ N	**A1**

Q19.

(b)(i)	for a body in (rotational) equilibrium	**B1**
	sum/total of clockwise moments about a point = sum/total of anticlockwise moments about the (same) point	**B1**
(b)(ii)	$(F_B \times 5.0)$ **or** (380×2.5) **or** (750×1.6)	**C1**
	$(F_B \times 5.0) = (380 \times 2.5) + (750 \times 1.6)$ $F_B = 430$ N	**A1**
(b)(iii)	taking moments about C: $(380 \times 2.5) = 750 \times (2.0 - x)$	**C1**
	$(2.0 - x) = 1.3$ $x = 0.7$ m	**A1**
	or	
	moments may be taken about other points, e.g. about D: $(380 \times 4.5) + (750 \times x) = 1130 \times 2.0$	**(C1)**
	$x = 0.7$ m	**(A1)**

Q20.

(c)(i)	tension = 560 – 200 = 360 N	**A1**

Q21.

(b)(iv)	constant velocity so no resultant force	**B1**
	no resultant force so in equilibrium	**B1**

Q22.

(b)(i)	frictional (force)/friction	**B1**
(b)(ii)	$W\cos 31° \times 3.0$ **or** 90×6.0	**C1**
	$W\cos 31° \times 3.0 = 90 \times 6.0$ $W = 210$ N	**A1**
(b)(iii)	$X = 90\sin 31°$ = 46 N	**A1**