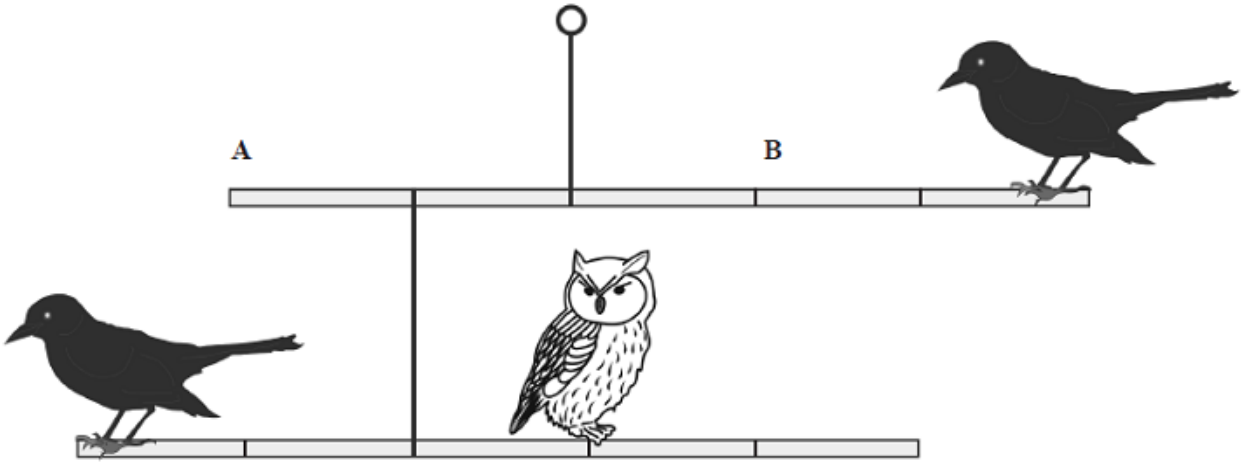

Explain, with the aid of a calculation, which type of bird sits at A and which type of bird sits at B to ensure the whole arrangement is in equilibrium.

(3)

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(Total for question = 4 marks)

Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
	C is the only correct answer	A is incorrect because the wrong trigonometric function has been used B is incorrect because the wrong trigonometric function has been used D is incorrect because the wrong algebraic equation has been used	**1**

Q2.

Question Number	Answer	Mark
	C	**1**
	Incorrect Answers: **A** – incorrect normal force direction **B** – incorrect normal force direction and frictional force direction **D** – incorrect frictional force direction	

Q3.

Question Number	Answer	Mark
	C	**1**

Q4.

Question Number	Answer	Additional Guidance	Mark
	• Use moment = $F\,x$ **(1)** • $x = 0.49$ m **(1)**	Example of calculation $6.5\ \text{N} \times (0.75\ \text{m} - x) = 3.5\ \text{N}\ x$ $4.875\ \text{Nm} - 6.5\ x = 3.5\ x$ $x = \frac{4.875\ \text{Nm}}{10\ \text{N}} = 0.488\ \text{m}$	**2**

Q5.

Question Number	Acceptable answers		Additional guidance	Mark
(i)	• Use of cos θ = vertical force ÷ applied force	(1)	Example of calculation cos θ = 50 N ÷ F F = 55.2 N	
	• Answer 55 N	(1)		2

Question Number	Acceptable answers		Additional guidance	Mark
(ii)	• Correct use of trigonometrical function to determine force in direction of motion	(1)	MP3 allow ecf from (b)(i) Example of calculation F = 55.2 N × sin 25° = 23.3 N $P = \frac{23.3\ \text{N} \times 15\ \text{m}}{4.2\ \text{s}}$ = 83.2 W	
	• Use of $W = Fs$ **and** $P = W/t$ **Or** use of $v = s/t$ **and** $P = Fv$	(1)		
	• P = 83 W	(1)		3

Q6.

Question Number	Answer		Mark
(a)(i)	Use of $W = mg$	(1)	
	Use of Tcos30 **Or** W/cos30 **Or** Tsin60 **Or** W/sin60	(1)	
	Factor of 4 seen/used	(1)	
	$T = 1.5 \times 10^{-3}$ N	(1)	4
	Example of calculation Weight = 5.4×10^{-4} kg × 9.81 N kg^{-1} = 5.30×10^{-3} N Vertical component of tension = T cos 30° $4T\cos 30° = 5.30 \times 10^{-3}$ N $T = 1.53 \times 10^{-3}$ N		
(a)(ii)	The tension has a horizontal component (as well) **Or** only the vertical component of the tension supports the weight	(1)	1
(b)	When under the twig (the stress/force is) tensile and when on top it is compressive	(1)	1
	Total for question		6

Q7.

Question Number	Acceptable answers		Additional guidance	Mark
	• Use of moment = force × perpendicular distance	(1)	MP1 not awarded if cos θ not used or sin θ not used Example of calculation (18.5 kg × 9.81 N kg^{-1}) × x cos θ = 50 N × 0.97 m × cos θ x = 0.27 m	3
	• Use of clockwise moments = anticlockwise moments	(1)		
	• Position of centre of gravity = 27 cm from base	(1)		

Q8.

Question Number	Acceptable answers		Additional guidance	Mark
	• The position of the centre of gravity moves to the left/backwards **Or** the perpendicular distance (from O) would be greater	(1)	MP1: accept lower for to the left	2
	• The moment of the bag (about O) increases so the moment of R (and the size of R) decreases to preserve equilibrium	(1)		

Q9.

Question Number	Acceptable Answer		Additional Guidance	Mark
(a)	• Use of $W = mg$	(1)	Example of calculation Mass of water = 85.0 litres × 1 kg = 85.0 kg	2
	• W = 868 (N)	(1)	Mass of base and water = 85.0 kg + 3.50 kg = 88.5 kg Weight of base = 88.5 kg × 9.81 N kg^{-1} = 868.2 N	

Question Number	Acceptable Answer		Additional Guidance	Mark
(b)	• See 868 N × 0.45 m × cos 15 (= 377.3 N m)	(1)	MP1 accept sin75 for cos15	
	• See 27 N ×2.0 m × cos 75 (= 13.98 N m)	(1)	MP2 accept sin15 for cos75	
	• See F_w ×2.4 m × cos 15 (= 2.31F_w)	(1)	MP3 accept sin75 for cos15	
	• Use of principle of moments e.g. substitution into: moment of weight of base = moment of weight of post arrangement + moment of wind	(1)	MP4, accept > correctly used in place of = to indicate the point at which it will tip and ecf for W from 11 (a)	
	• F_w = 157 or 158 N	(1)	Example of calculation (using perpendicular forces) Moment of weight of base = 868 N × cos 15 × 0.45 m = 377.29 Nm Moment of the post arrangement = 27.0 N × cos 75 × (2.80 m – 0.80 m) = 13.98 N m Moment of the wind = F_w × cos 15 × 2.40 m = 2.31 F_w 377.29Nm = 13.98 Nm + 2.31 F_w F_w = 157.28 N Example of calculation (using perpendicular distances) (868 N × 0.45 m × cos 15) = (27 N ×2.0 m × cos 75) + (F_w ×2.4 m × cos 15) F_w = 156.72 N	5

Question Number	Acceptable Answer		Additional Guidance	Mark
(c)	• F_w would increase	(1)		
	• The weight of the base would be heavier/increase	(1)		
	• This increases the clockwise moment **Or** this increases the moment of the (weight of the) base	(1)		3

Q10.

Question Number	Acceptable answers	Additional guidance	Mark
(i)	**MAX 2** • Statement describing 740cos20 as the (perpendicular) component of weight of the hiker **and** Statement describing Wcos20 as the (perpendicular) component of the weight of the bag **(1)** **(1)** • 2R is the push of the ground on the hiker **(1)** • Use of $\Sigma F = 0$ with reference to hiker being stationary	Accept reaction force	**2**

Question Number	Acceptable answers	Additional guidance	Mark
(ii)	• See 740 N × 0.25 m × cos 20 (= 173.8 N m) **(1)** • See W × 0.10 m × cos 20 (= 0.0940W N m) **(1)** • See R × 0.40 m (= 0.40N N m) **(1)** **Or** 0.5(740cos20 + Wcos20) • Use of principle of moments e.g. substitution into: moment of weight of man = moment of weight of bag + moment of R **(1)** • Use of equation of the resultant force with the equation obtained in MP4 **(1)** **OR** **(1)** Use of principle of moments about another point with the equation obtained in MP4 • W = 120 N	Example of calculation Moment of the weight of the man: 740 N × 0.25 m × cos 20 = 173.8 N m Moment of the weight of the bag: W × 0.10 m × cos 20 = 0.0940W N m Moment of R: R × 0.40 m = 0.40R N m 173.8 N m = 0.40R + 0.0940W N m Re-arranging to make R the subject of the equation: R = 435 N – 0.235W N Re-arranging the equation for the resultant force: R = 347.7 N + 0.470W 435 N – 0.235W N = 347.7 N + 0.470W 0.705W = 87.3 W = 124 N	**6**

Q11.

Question Number	Acceptable answers	Additional guidance	Mark
	• The weight does not act through the nail/pivot **Or** the centre of gravity is not in line/below the nail/pivot **Or** there is a perpendicular distance between the weight and the nail/pivot (1) • There is now a moment of the weight **Or** the anticlockwise moment is greater than the clockwise moment (1) • The idea that the picture stops moving when the c of g is below the nail (1)	Accept centre of mass for centre of gravity (Allow annotations to a diagram with additional explanation for MP1/3) MP3 Accept: the turning moment being 0 **Or** the clockwise moments equal to the anti-clockwise moments	3

Q12.

Question Number	Acceptable answers	Additional guidance	Mark
(i)	• shows clockwise moment = anticlockwise (1)	Example of calculation M.2 = 2M.1	1
(ii)	• Moment of 3M associated with 1 (1) • Takes moments around suspension (1) • crow at A and owl at B (1) Alternative scheme for MP2 and MP3: • Show that, without the extra birds, it balances (1) • So added birds must be crow at A and owl at B, as in part (i) (1)	Example of calculation 3M.1 + x.2 = M.3 + y.1 2x = y So y must be an owl and x the crow	3