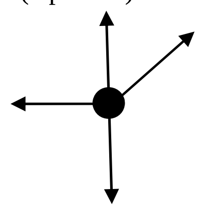
Question Number	Answer	Mark
1(a)(i)	Tension line and arrow correctly drawn and labelled **(1)** Weight line and arrow correctly drawn and labelled **(1)**  (Tension can be on either side. If 2 marks have been awarded subtract 1 mark if the drag has been included and is not a horizontal force opposing the tension)	**2**
1(a)(ii)	Use of correct trig function to find horizontal component of the tension **(1)** $T_{horizontal}$ = 840 (N) **(1)** <u>Example of calculation</u> Horizontal component of tension = $T\cos\theta$ $T_{horizontal}$ = 1100 N × cos 40° $T_{horizontal}$ = 843 N	**2**
1(a)(iii)	$T_{vertical}$ = 1100 sin 40° **Or** $T_{vertical}$= 707 (N) seen **(1)** Use of $W = mg$ **(1)** Use of $mg = U + T_{vertical}$ with a sensible statement discussing what would happen if $T_{vertical}$ = W **Or** $T_{vertical}$ > weight **Or** $T_{vertical}$ < weight **(1)** e.g. $T_{vertical}$ = W **Or** mass = 72 kg: Upthrust is zero $T_{vertical}$ > weight **Or** mass < 72 kg: Can't have a negative upthrust $T_{vertical}$ < weight **Or** mass > 72 kg : To provide some upthrust <u>Example of calculation</u> $T_{vertical} = T \sin 40°$ (= 707 N) **OR** $mg = U + T_{vertical}$ $mg = U + 707$ N mass = $\frac{707 \text{ N}}{9.81 \text{ N kg}^{-1}}$ = 72.1 kg	**3**

*1(b)	**(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)** C **(1)** **Max 3** The horizontal component of the tension in the line produces the forward force acting on the surfer **Or** horizontal component of tension = $T\cos\theta$ (accept $T_{horizontal} = 1100\cos\theta$) **(1)** As the angle to the horizontal (θ) decreases **Or** As the angle to the vertical (θ) decreases ➔ $T\cos\theta$ increases **Or** the forwards force on the surfer increases **Or** the smallest θ gives the maximum/greatest force **(1)** Work done increases **(1)** Power transferred to surfer= $\frac{\text{work done}}{\text{time}}$ has increased hence the power increases **Or** more work done per second on the surfer so the power increases **(1)**	**4**
	Total for question	**11**

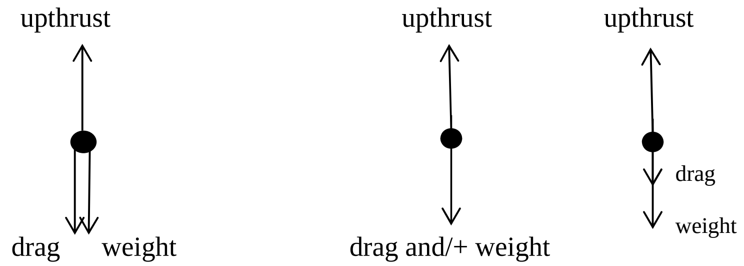
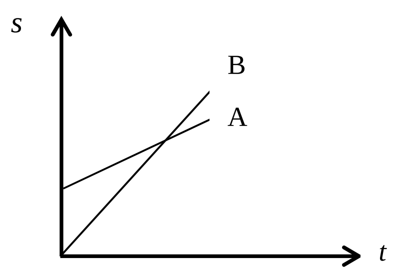
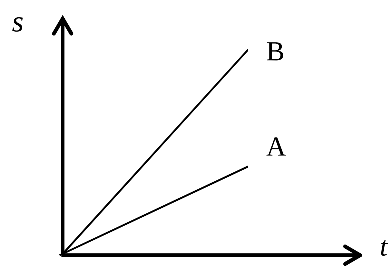
Question Number	Acceptable Answers	Mark
2(a)	**Laminar**: Continuous lines, not crossing, below the wing, with at least 2 continuing beyond the wing **(1)** **Turbulent:** swirls, crossing lines, changes of direction greater than 90° **only** above the wing, not necessarily attached to the lines from the left **(1)**	**2**

Question Number	Acceptable Answers	Mark
2(b)(i)	The idea that a (component of) lift = weight **(1)** See *L* cos 20° or *mg* / cos 20° **(1)** *L* = 0.66 or 0.7 (N) **(1)** <u>Example of calculation</u> Vertical component of lift = weight $L\cos 20^{o} = 0.063\ \text{kg} \times 9.81\ \text{N kg}^{-1}$ *L* = 0.66 (N)	**3**

Question Number	Acceptable Answers	Mark
2(b)(ii)	Find the horizontal component of lift (drag) using trig or Pythagoras **(1)** (L sin 20°, W tan 20°, $\sqrt{L^2 - W^2}$) Use of $F = ma$ **(1)** Acceleration = (−) 3.6 to 3.7 m s^{-2} (ecf) **(1)** <u>Example of calculation</u> $L_{horizontal} = -L\sin 20 = -0.66\ \text{N} \times \sin 20 = -0.226\ (\text{N})$ $\text{acceleration} = \frac{-0.226\ \text{N}}{0.063\ \text{kg}}$ acceleration = −3.57 m s^{-2}	**3**

Question Number	Acceptable Answers	Mark
2(c)(i)	Bird/leg exerts force/push (down) on ground **(1)** <u>N3</u> ground exerts a force (up) on bird **(1)** Force ≠ / > weight **Or** there is a resultant/unbalanced force **(1)** Due to <u>N2 / N1</u> bird accelerates **(1)**	**4**

Question Number	Acceptable Answers	Mark
2(c)(ii)	Maximum force read from graph = 2.00 N to 2.10 N **(1)** resultant force = $F - W$ (1.37 N to 1.43 N) **(1)** Answer = 23 m s^{-2} **(1)** <u>Example of calculation</u> Maximum force = 2.05 N 2.05 N – (0.063 kg x 9.81 m s^{-2}) = 0.063 kg × a a = 22.7 m s^{-2}	**3**
	Total for question	**15**

Question Number	Answer	Mark
3(a)(i)	Weight/*W*/*mg* **(1)** Upthrust/*U* **(1)** Drag/Friction/Fluid resistance/*F*/*D*/*V* **(1)** (all lines must touch the black dot and should be approximately vertical by eye) (−1 for each additional force) 	3
*3(a)(ii)	(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate) <u>Upthrust</u> is greater for the larger bubble **(1)** Drag/friction increases **(1)** Upthrust increases more than drag **Or** greater (initial) resultant force on bubble **Or** higher terminal velocity **Or** upthrust is related to volume/radius^3 **and** drag related to area/radius$^{(2)}$ **(1)**	3
3(b)(i)	Both graphs straight from t = 0 (labels not required) **(1)** Initial gradient of A less than gradient of B (minimum of 1 label required) **(1)** (The lines do not have to meet i.e. the lines could stop before the meeting point The lines can start anywhere on the displacement axes) 	2

3(b)(ii)	Measurement from photographs 0.5 - 0.7 (cm) Use of distance = measurement × 12 Use of speed = distance/time speed = 0.18 – 0.25 m s $^{-1}$ <u>Example of calculation</u> Measurement = 0.55 cm Distance = 0.55 × 10^{-2} m× 12 = 6.6 × 10^{-2} m speed = $\frac{6.6 \times 10^{-2}\ \text{m}}{0.33\ \text{s}}$ speed = 0.20 m s^{-1}	**(1)** **(1)** **(1)** **(1)**	**4**
3(c)(i)	(Stokes' law is only for) small (solid) spheres **Or**(Stokes' law is only for) laminar flow **Or** there is turbulent flow Additional/less drag due to the bubbles having a non-stationary surface **Or** Stokes' law cannot be applied to a gas bubble because they have a non-stationary surface **Or** sides of container too close to bubbles **Or** volume/shape changes as it rises	**(1)** **(1)**	**2**
***3(c)(ii)**	(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate) **Either: Resultant forces method 4 marks** Measure the diameter/radius of the sphere (from the photograph) Use of $4\pi r^3/3$ to find the volume of the sphere Use $V\rho g$ to find the upthrust / weight of the bubble Drag = upthrust – weight **Or: Stokes' law method 2 marks** Measure the diameter/radius of the sphere (from the photograph) Calculate the (terminal) velocity using $v = s/t$ **and** substitute into $F = 6\pi r\eta v$	 **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**4**
	Total for question		**18**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>4(a)</td><td>
Use of pythagoras Or trigonometry to find the resultant velocity (1)
$v = 1.9\ \text{m s}^{-1}$ (1)
Use of trig to find the direction (1)
Direction = 54° (1)

<u>Example of calculations</u>
$v = \sqrt{(1.1\,\text{m s}^{-1})^2 + (1.5\,\text{m s}^{-1})^2}$

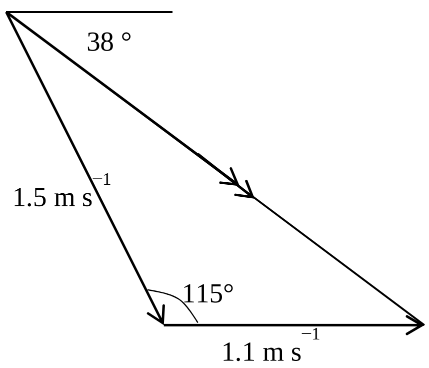
$v = 1.86\ \text{m s}^{-1}$

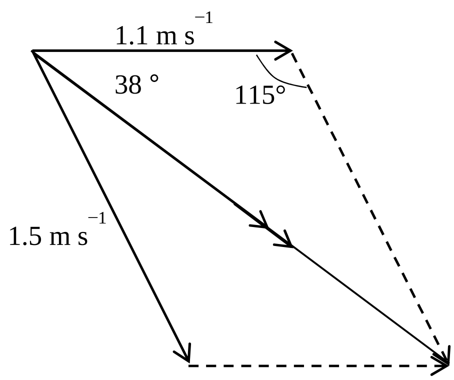
$\text{Direction} = \tan^{-1}\dfrac{1.5\,\text{m s}^{-1}}{1.1\,\text{m s}^{-1}}$
Direction = 53.74 °
</td><td>4</td></tr>
<tr><td>4(b)</td><td>
Construction of a correct vector triangle or parallelogram (from which a measurement for the resultant could be made) (1)

$v = 2.2 \pm 0.1\ \text{m s}^{-1}$ (1)

Direction = 38 ± 2° (1)

(Correct answers calculated mathematically rather than with a vector diagram will only score MP2 and MP3)





</td><td>3</td></tr>
<tr><td></td><td>Total for question</td><td>7</td></tr>
</table>

Question Number	Answer		Mark
5	Newton's 3rd law: The minimum: Every action has an equal and opposite reaction **OR** More detail: An object A exerts a force on object B then object B exerts an equal and opposite force on object A	**(1)**	
	• Forces act on different bodies **OR** forces act on the road and the tyre	**(1)**	
	• Forces act in <u>opposite directions</u> **OR** (directions of the) forces are backwards and forwards	**(1)**	
	• Forces have same magnitude/size **OR** both forces are 300 N	**(1)**	
	• Forces are of same kind **OR** forces are both are (frictional) contact forces/friction	**(1)**	**5**
	Total for question		**5**