Question Number	Answer		Mark
1(a)(i)	R= 9.32 kN Example of answer R = 950 kg × 9.81 m s^{-2} R = 9320 N	**(1)**	**1**
1(a)(ii)	Use of $F = mv^2/r$ $R = mg - mv^2/r$ R = 2480 N ecf their value of R Example of calculation R = 9320 N − (950 kg × 12.0^2 m^2 s^{-2} / 20.0 m) R = 2480 N	**(1)** **(1)** **(1)**	**3**
1(b)	An answer that either states implicitly or implies that 'The required centripetal force > mg and so cannot be provided'.	**(1)**	**1**
	Total for question 11		**5**

Question Number	Answer		Mark
2(a)(i)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate there is a magnetic field in stator/(iron) core **Or** the core becomes an electromagnet This field/flux is changing (due to the AC input) *B* field (from the stator) passes through the rotor (the changing magnetic flux/field leads to an) induced emf/pd	**(1)** **(1)** **(1)** **(1)**	**4**
2(a)(ii)	Rotor experiences a force **Or** mention of FLHR **Or** $F = BIl$ Due to the current in the **rotor** being in a magnetic field **Or** rotor becomes a magnet	**(1)** **(1)**	**2**
2(a)(iii)	**Max 2** Increase frequency (of current) Increase (magnitude of) current Add more turns (to either coil)	 **(1)** **(1)** **(1)**	**2**
2(b)(i)	T = 60/33(1,82 s) **Or** f =33/60 (0.55 s^{-1}) Use of $\omega = 2\pi/T$ **Or** $w = 2\pi/f$ ω= 3.5 rad s^{-1} [11.4 rad s^{-1} scores 1; 3.2 x 10^{-3} rad s^{-1} scores 1; 11 π/10 rad s^{-1} scores 2] Example of calculation $\omega = (33 \times 2\pi)/ 60$ s ω= 3.5 rad s^{-1}	**(1)** **(1)** **(1)**	**3**
2(b)(ii)	Use of $a = r\omega^2$ a = 1.5 ms^{-2} [allow ecf from (b)(i)] [11.4 rad s^{-1} gives 16 m s^{-2}] Example of calculation $a = (0.125 \text{ m}) \times (3.5 \text{ rad s}^{-1})^2$ a = 1.5 m s^{-2}	**(1)** **(1)**	**2**
	Total for question 15		**13**

Question Number	Answer	Mark
3(a)(i)	Calculation of time period (1) Use of $v = \frac{\Delta s}{\Delta t}$ *or* $\omega = \frac{2\pi}{T}$ (1) Use of $a = \frac{v^2}{r}$ *or* $a = r\omega^2$ (1) Correct answer (1) Example of calculation: $T = \frac{24 \times 60 \times 60\, s}{15} = 5760\, s$ $v = \frac{2\pi r}{T} = \frac{2\pi \times 6.94 \times 10^6\, m}{5760\, s} = 7.57 \times 10^3\, ms^{-1}$ $a = \frac{v^2}{r} = \frac{\left(7.6 \times 10^3\, ms^{-1}\right)^2}{6.94 \times 10^6\, m} = 8.26\, ms^{-2}$ OR $\omega = \frac{2\pi}{T} = \frac{2\pi}{5760\, s} = 1.09 \times 10^{-3}\, ms^{-1}$ $a = r\omega^2 = 6.94 \times 10^6 \times \left(1.09 \times 10^{-3}\right)^2 = 8.26\, ms^{-2}$	**(4)**
3(a)(ii)	mg equated to gravitational force expression (1) g (= a) = 8.3 ms^{-2} substituted (1) Correct answer (1) Example of calculation: $mg = \frac{GMm}{r^2}$ $\therefore 8.3\,ms^{-2} = \frac{6.67 \times 10^{-11}\, N\, m^2\, kg^{-2} M}{\left(6.94 \times 10^6\, m\right)^2}$ $\therefore M = \frac{8.3\, ms^{-1} \times \left(6.94 \times 10^6\, m\right)^2}{6.67 \times 10^{-11}\, Nm^2 kg^{-2}} = 6.0 \times 10^{24}\, kg$	**(3)**
3(b)	The observed wavelength is longer than the actual wavelength / the wavelength is stretched out (1) One from: The universe is expanding (1) (All distant) galaxies are moving apart (1) The (recessional) velocity of galaxies is proportional to distance (1) The furthest out galaxies move fastest (1)	**(max 2)**

3(c)(i)	A light year is the distance travelled (in a vacuum) in 1 year by light / em-radiation (1) The idea that light has only been able to travel to us for a time equal to the age of the universe. (1)	**(2)**
3(c)(ii)	(Use of $v = H_o d$ to show) $H_o = \frac{1}{t}$ (1) Correct answer (1) Example of calculation: $H_o = \frac{1}{t} = \frac{1}{12 \times 3.15 \times 10^{16}\ s} = 2.65 \times 10^{-18}\ s^{-1}$	**(2)**
3(c)(iii) **QWC**	The answer must be clear and be organised in a logical sequence There is considerable uncertainty in the value of the Hubble constant (1) Any sensible reason for uncertainty (1) Idea that a guess implies a value obtained with little supporting evidence OR the errors are so large that our value is little better than a guess (1)	**(3)**
	Total for question	**(16)**

Question Number	Answer	Mark
4(a)	The weight of the moon **Or** the gravitational force of the Earth (on the moon) **(1)** The (mass of the Earth and) speed/velocity of the moon **(1)**	**2**
4(b)	A centripetal / unbalanced force is needed (because the water is moving in a circular path) **(1)** **Max 2** At the highest point the (unbalanced) force is weight of water plus reaction from bucket **(1)** Idea that the minimum force needed (towards the centre of the circle) is the weight of the water **(1)** Minimum velocity where $\frac{mv_{min}^2}{r} = mg$ **Or** $v_{min}^2 = rg$ **(1)** [Credit may be given for a diagram with appropriate annotations]	**Max 3**
	Total for question 16	**5**

Question Number	Answer		Mark
5(a)	Velocity/direction changing **Or** (object is) accelerating Force towards centre of circle	**(1)** **(1)**	**2**
5(b)	High(er) speed means large(r) force **Or** small(er) radius means large(r) force (For sharp bends) centripetal/resultant/required <u>force</u> would need to be greater than maximum frictional force **Or** (for sharp bends) friction cannot provide the (required) centripetal/resultant force	**(1)** **(1)**	**2**
5(c)(i)	Resolving forces vertically $\underline{N} \sin\theta = mg$ Resolving forces horizontally $\underline{N} \cos\theta = mv^2/r$ Division of vertical equation by horizontal equation to get correct answer	**(1)** **(1)** **(1)**	**3**
5(c)(ii)	Use of $\tan\theta = gr/v^2$ $\theta = 57^o$ <u>Example of calculation</u> $\tan\theta = (9.81 \text{ m s}^{-2} \times 18.7 \text{ m})/ (11.0 \text{ m s}^{-1})^2$ $\theta = 56.6^o$	**(1)** **(1)**	**2**
	Total for question 16		**10**