Question Number	Answer	Mark
2(a)	Evidence of frictional force = (0.35 × mg) **(1)** Use of $F = mr\omega^2$ **Or** $F = mv^2/r$ **(1)** Use of $\omega = 2\pi/T$ **Or** $v = 2\pi r/T$ **(1)** t = 3.0 s **(1)** Example of calculation frictional force = 0.35 × 20 kg × 9.81 m s^{-2} = 68.7 N $F = mr\omega^2$ $\omega = \sqrt{}$ (68.7 N / (20 kg × 0.80 m) ω =2.1 rad s^{-1} $t = 2\pi/2.1$ rad s^{-1} t = 3.0 s	**4**
2(b)	There would be no difference **(1)** Both expressions for force depend on mass **Or** algebraic equation for ω or T derived (could be in the working for (a)) showing ω or T independent of m **Or** statement that masses cancel if supported by evidence in (a) **(1)**	**2**
	Total for question 13	**6**

Question Number	Answer	Mark
4(a)	Conversion from per minute to per second **(1)** Conversion from revolutions to radians **(1)** Example of calculation 20 revolutions = 20 x 2π /60 (= 2.1 rads s^{-1})	
4(b)	Use of $r\omega^2$ **(1)** Answer in range 6 – 13 **(1)** ms^{-2} **(1)**	
	Total for question 13	**5**

Question Number	Answer	Mark
5(a)	Use of $F=mv/t$ or $F = ma$ **(1)** Answer = 2.0 x 10^5 N **(1)** Eg F = 12000 x 57 / 3.5	**2**
5(b)	Arrow down labelled mg / W **(1)** Arrow up labelled eg R /reaction / force from seat **(1)** Equal length vertical arrows from a clear single point / centre of mass and "bottom" **(1)**	**3**
5(c)	$4mg - mg$ OR $3mg$ **(1)** $(m)v^2/r$ seen **(1)** Answer = 110 (m) **(1)**	**3**

	Eg $3mg = mv^2 / r$ $r = (57)^2 / 3g$	
5(d)	Use of KE / PE conservation **(1)** Answer = 23 (m s^{-1}) **(1)** Eg $\frac{1}{2} m(57)^2 = \frac{1}{2} mv^2 + mg139$ $v^2 = \frac{1}{2} (57)^2 - 9.81x139$	**2**
5(e)	Using $(m)g$ only **(1)** Answer r = 54 m [allow ecf] **(1)** **Eg** $mg = mv^2 / r$ $r = (23)^2 / 9.81$	**2**
	Total for question	**12**

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 $\tan \theta = gr/v^2$ $\theta = 57^\circ$ <u>Example of calculation</u> $\tan \theta = (9.81 \text{ m s}^{-2} \times 18.7 \text{ m})/ (11.0 \text{ m s}^{-1})^2$ $\theta = 56.6^\circ$	**(1)** **(1)**	**2**
	Total for question 16		**10**

MCQ Answers:

5) B
6) D