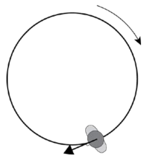
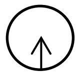
Level 2 Physics: Mechanics – Circular Motion Answers

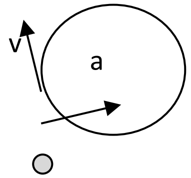
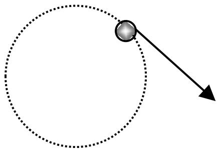
Question	Evidence	Achievement	Merit	Excellence
2020(2) (a)	Arrow towards centre.	Correct answer.		
(b)	$a = \frac{v^2}{r} = \frac{12^2}{25} = 5.76 \text{ m s}^{-2}$ Unbalanced inward force created by friction causes inward acceleration	Correct calculation. OR Unbalanced inward force created byfriction causes inward acceleration.	BOTH correct	
(c)	If the car hits ice / oil / gravel / wet road / or tyre condition • this will change the friction forces and either reduce or increasecentripetal force • and so direction will change due to change in unbalanced forces.	ONE factor that causes reduction infriction.	external factor named PLUS Reduced friction leads to reduced *Fc* resulting in tangential motion	
2019(2) (a)	$v = \frac{2\pi r}{T} = \frac{2\pi \times 0.5}{1.4} = 2.24 \text{ m s}^{-1}$	Correct equation and substitution		

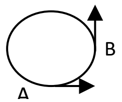
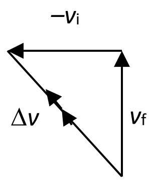
(b)	$F = \frac{mv^2}{r} = \frac{0.04 \times 2.24^2}{0.5} = 0.40\text{ N}$ (The force supplied by) the tension in the string (is perpendicular to the velocity of the whistle and) provides the centripetal force/force towards the centre/unbalanced force perpendicular to the velocity (this keeps the whistle moving in a circle at a constant speed).	Correct force calculated (evidence can be drawn from 2(c)). OR Valid explanation	Correct force calculated (evidence can be drawn from 2(c)). AND Centripetal / perpendicular force linked to circular motion	
(c)	The new force would be 0.08 N using Force = $\frac{mv^2}{r}$ with $v = 1\text{ m s}^{-1}$. This would not be sufficient to keep the whistle in circular motion at the same radius, and so the whistle would move in a circle with a smaller radius. The string would drop down/ be more angled down	New force calculated OR Statement that force decreases. OR Statement that whistle/string drops down.	New force calculated AND Whistle would either fall out of circular motion or the radius would have to diminish.	

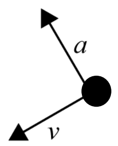
2017(3) (d)	$v = \frac{2\pi r}{t} = \frac{2\pi \times 0.6}{0.80} = 4.71 \text{ m s}^{-1}$ OR $v = \frac{2\pi r}{T} = \frac{5 \times 2\pi \times 0.6}{4.0} = 4.71 \text{ m s}^{-1}$ $F = \frac{mv^2}{r} = \frac{0.05 \times 4.71^2}{0.6} = 1.85 = 1.9 \text{ N}$	Correct speed calculated. OR Incorrect speed but consequently correct force.	Correct velocity. AND Correct force.	
2016(1) (d)(i) (ii)	Centripetal or friction force, acting towards the centre. As this force is acting towards the centre of the circle, it changes the direction of the car's velocity (makes the car go around the circle). As this force is acting at 90° to the direction of travel of the car, it does not change the size of the velocity.	Correct name and correct direction of the force. OR One correct effect of the force.	Correct name and correct direction of the force. AND ONE correct effect of the force with reason.	Correct name and correct direction of the force. AND BOTH correct effects of the force.
2015(4) (a)	Even though the ball is travelling at constant speed, it is changing its direction of motion continuously. A change in either speed or direction is acceleration, hence the ball in circular motion is accelerating.	Correct answer.		
(b)	$v = \frac{2\pi r}{T} = \frac{2 \times \pi \times 0.75}{0.84} = 5.61 \text{ m s}^{-1}$ $a = \frac{v^2}{r} \rightarrow a = \frac{5.612}{0.75} = 42 \text{ m s}^{-1}$	Correct answer for velocity. OR a calculated correctly with carryover.	Correct answer.	
(c)	The tension in the cord provides centripetal force, which is the unbalanced force (*causing acceleration*).	Tension provides the centripetal force.	Recognition that tension is the unbalanced force (*that causes acceleration*).	

2014(3) (d)	Before she reaches the ice, there is a net friction force towards the centre of the curve. This causes the car to accelerate towards the centre without changing speed / provides a centripetal force allowing the car to move in a circular path. (After she reaches the ice, there is no longer any friction.) The net force on the car is zero, so it will keep travelling at constant speed at a tangent to the curve/in a straight line.	ONE correct idea – may be represented on the diagram.	TWO correct ideas.	ALL ideas clearly linked.

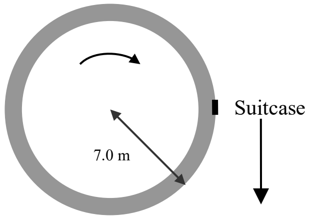
Question	Achievement	Merit	Excellence
2013(1) (a)			
(b)	$v = \frac{2\pi r}{T} = \frac{2\pi \times 4}{15} = 1.68 \text{ ms}^{-1}$ OR Used incorrect value of "v" to calculate F_c	$F_c = \frac{mv^2}{r} = \frac{65 \times 1.68^2}{4} = 45.6 \text{ N}$ = 46 N	
2012(1) (d)	 Arrow towards centre of circle.		
(e)	Hannah is moving in a circle so there must be a centripetal force on her. OR The centripetal force is provided by the rope (tension).	Hannah is moving in a circle so there must be a centripetal force on her. AND The centripetal force is provided by the rope(tension).	At the lowest point of her swing, the unbalanced force, the centripetal force, is the difference between the tension force acting upwards and the gravity force acting vertically down. It is this unbalanced force that causes her to move in a circle.

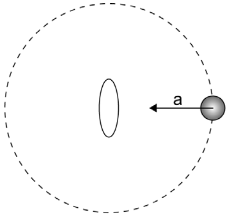
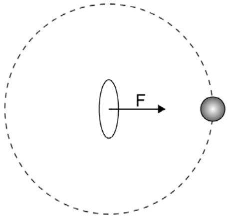
Question	Evidence	Achievement	Merit	Excellence
2011(1) (d)	Friction between the tyres and the road provides (centripetal) force. This acts towards the centre of the circle.	[1] States friction between tyres and road (not enough to say just friction). OR The direction of the force is towards the centre of the circle.	[1] States friction between tyres and road (not enough to say just friction). AND The direction of the force is towards the centre of the circle.	
2010(1) (a)		[1] Both correct. Must have labels, arrows and must be at right angles to each other.		
(b)	 There is no horizontal unbalanced force on the discus. Since there is no unbalanced force, there is no acceleration, and hence it travels in a straight line.	[1] Correct direction for arrow.	[1] There is **no unbalanced force**, so it travels in a straight line. OR **No acceleration** and hence travels in a straight line.	[1] There is **no acceleration**, due to the absence of an unbalanced force, and hence it travels in a straight line.

(c)	$F = \frac{mv^2}{r}$ $290 = \frac{2.1 \times 11^2}{r}$ $r = \frac{2.1 \times 11^2}{290}$ $r = 0.88$ m	[2] Correct working except for one error. If candidate has substituted correctly for $290 = \frac{2.1 \times 11^2}{r}$ OR If candidate has transposed incorrectly and got $r = \frac{290}{2.1 \times 121}$	[2] Correct working and answer.	
2009(1) (a)	Acceleration arrow to point towards the centre of the circle.	[1] Acceleration arrow correct.		
(b)	$a = \frac{v^2}{r} \Rightarrow a = \frac{5.0^2}{1.59}$ $a = 15.7 ms^{-2} = 16 ms^{-2}$	[2] Correct answer including unit.		
(c)	 $\Delta v = v_f - v_i$  $\Delta v = \sqrt{5.0^2 + 5.0^2}$ $\Delta v = \sqrt{50} = 7.07$ m s^{-1} $\theta = \tan^{-1}\left(\frac{5}{5}\right) = 45°$	[2]Velocity arrows drawn correctly on diagram for both positions A and B. OR Value of resultant calculated with incorrect vector diagram.	[2]Velocity arrows drawn correctly on diagram for both A and B AND Vector diagram drawn correctly OR Value of resultant velocity calculated correctly with incorrect direction for resultant velocity vector.	[2]Velocity arrows drawn correctly on diagram for both A and B AND Vector diagram drawn correctly, and resultant velocity calculated correctly with correct direction.

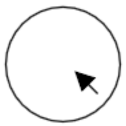
2008(2) (a)		[1]Velocity vector must be tangential on Tahi or the edge of the merry-go-round. Acceleration vector must act from Tahi toward the centre.		
(b)	Centripetal acceleration.	[1]Correct answer.		
(c)	$a = \frac{v^2}{r} = \frac{1.5^2}{3} = 0.75 \text{ m s}^{-2}$	[2]Correct answer.		
(d)	There must be a force acting towards the centre of the circle as Tahi is constantly changing direction. If Tahi is constantly changing direction, then he is accelerating and acceleration requires a force. OR There must be a force acting towards the centre of the circle as he is constantly changing direction. Without a force Tahi would travel in a straight-line tangent to the circle.	[1]The force acts towards the centre (don't accept centripetal or inward). OR A force is needed to change the direction of Tahi. *(Don't accept keep going in a circle.)* OR Without a force Tahi would travel in a straight line (tangent to the circle).	[1]Links a centre acting force TO a constant change in the direction. OR That without a centre acting force Tahi would travel in a straight-line tangent to the circle.	[1]Fully correct answer.

(e)	For Rua to halve the period he must make the merry-go-round spin at twice the speed as $v = \frac{d}{t}$. As $F = \frac{mv^2}{r}$ if the speed doubles, then the centripetal force is quadrupled assuming that the mass and radius remain constant.	[1]Qualitative answer identifying that the force increases.	[1]Quantitative answer with valid formulaic reasons.	[1]Fully quantitative answer stating quadruple the force, justified using relevant formula or stating the assumptions that mass and/or radius remain constant.

Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
2007(3) (a)		[1]Any arrow that shows a tangential **direction.** (Accept if arrow drawn tangentially at the end of the radius arrow).		
(b)	This is because the object is continually changing direction even though the speed remains the same. A change in direction amounts to a change in velocity as velocity is a vector. The rate of change of velocity is acceleration.	[1]States direction is continually changing. OR States that a centripetal force is acting on the suitcase.	[1]**Links** changing direction to the vector nature of velocity. OR **Links** changing direction to centripetal force.	[1]**MERIT plus…** **Links** changing velocity to acceleration. OR **Links** centripetal force to centripetal acceleration.
(c)	$F = \frac{mv^2}{r}$ hence $v = \sqrt{\frac{Fr}{m}}$ $v = \sqrt{\frac{5.5 \times 7.0}{18}} = 1.463$ d = 2πr = 2π×7.0 = 43.982 $T = \frac{d}{v}$ $T = \frac{43.982}{1.463} = 30.07$ s	[2]Correct velocity. OR Correct circumference.	[2]Any two correct processes.	[2]Correct working and answer (Do not accept rounding for excellence if it causes a change in the significant figure answer.

2006(2) (a)		[1]Correct direction and label.		
(b)		[1]Correct direction and label.		
(c)	The ball has a constant speed but is changing direction and so its velocity is changing. This means it is accelerating. This acceleration requires a centripetal force. As the force is at 90˚ to the direction of motion the ball will travel at a constant speed.	[1]A force is needed to change the direction of the ball. OR Without a force the ball would travel in a straight line (tangent to the circle).	[1]**Achieved plus** Reference to centripetal force /centre acting force /force perpendicular to direction of motion.	[1]**Merit plus** The direction of the force is perpendicular to the direction of motion resulting in constant speed**.**

(d)	$C = 2\pi r = 2 \times \pi \times 2.0 = 12.57$ m $v = \frac{d}{t} = \frac{12.57}{1.5} = 8.38\ \text{ms}^{-1}$ $F = \frac{mv^2}{r} = \frac{10 \times 8.38^2}{2.0} = \mathbf{350.9\ N}$ **OR** $F = \frac{mv^2}{r}$ $F = \frac{4\pi^2 mr}{T^2} = \frac{4\pi^2 \times 10 \times 2}{1.5 \times 1.5} = 350\ \text{N}$	[2]Correct calculation of circumference.	[2]Correct calculation of velocity. **OR** Correct use of centripetal force equation but calculates velocity using radius instead of circumference.	[2]Correct working and answer.
(e)	Shorter period means greater speed. Therefore, greater centripetal force acting on iron ball**.** Therefore, the reaction force acting on Jan will be greater (Newton's 3rd law).	[1]Greater force.	[1]**Achieved plus** Links greater speed to greater force on ball**.**	[1]**Merit plus** Clear understanding of reaction force.
2005(1) (g)(i)	Arrow on car pointing in towards the centre of the circle at right angles to the direction of travel.	[1]Arrow drawn correctly.		
(g)(ii)	$F = \frac{mv^2}{r} = \frac{1357 \times 25^2}{40} = 2.1 \times 10^4\ \text{N}$	[2]Correct answer.		
	Answer written with 1 or 2 sig figs.	[1]Answer written appropriately.		

(g)(iii)	The car would slide in a straight line **at a tangent** to the direction that it was travelling **at a constant speed**. There is no longer any friction between the tyres and the road to provide the **centripetal force** needed to maintain the car moving in a circular path.	[1]**EITHER** travels (in a straight line) at a tangent to the circle. **OR** Travels at a constant speed. **OR** Absence of friction means that there is no centripetal force holding it to its circular path.	[1]Any two different and correct ideas.	[1]Completely correct answer.
2004(4) (e)		[1]Arrow points towards centre of circle.		
(f)	$F_c = \frac{mv^2}{r}$ $v = \sqrt{\frac{F_c \times r}{m}} = \sqrt{\frac{500 \times 0.95}{55}} = 2.939$ $v = 2.9 \text{ m s}^{-1}$	[2]Correct formula quoted, **and** correct values substituted.	[2]Correct answer.	
	s.f. $v = 2.9 \text{ m s}^{-1}$ (2 s.f.)	[1]Two significant figures.		
(g)(i)	Ana would travel at a constant **speed** in a straight line in the **direction** that she was moving when Jon let go, at a tangent to the circle.	[1]Either travels (in a straight line) at a tangent to the circle *OR* travels at constant speed.	[1]Travels in a straight line at a tangent to the circle *AND* at constant speed.	

(g)(ii)	Ana travels at a tangent to the circle (in a straight line) due to the loss of the centripetal force provided by Jon. She travels at constant speed because the ice provides no friction.		[1]Links tangential movement to absence of Jon's force *OR* links constant speed to absence of friction.	[1]Links tangential movement to absence of Jon's force *AND* links constant speed to absence of friction.

The Mess that is NCEA Assessment Schedules….

Level 2 Physics: **AS 91171** replaced **AS 90255.**

In 90255, from **2003 to 2011**, there was an Evidence column with the correct answer and Achieved, Merit and Excellence columns explaining the required level of performance to get that grade. Each part of the question (row in the Assessment Schedule) contributed a single grade in either Criteria 1 (Explain stuff) or Criteria 2 (Solve stuff). From 2003 to 2008, the NCEA shaded columns that were not relevant to that question.

In 91171, from **2012 onwards**, the answers/required level of performance are now within the Achieved, Merit and Excellence columns. Each part of a question contributes to the overall Grade Score Marking of the question and there are no longer separate criteria. There is no shading anymore. At least their equation editor has stopped displaying random characters over the units.

And **in 2013**, with 91171, we still have no Evidence column with the correct answer and Achieved, Merit and Excellence columns explaining the required level of performance to get that part – even though the other two Level 2 Physics external examinations do!!

And now in **2014 - 2017**, we have the Evidence column back……