Roller coaster

The roller coaster originated in Russia over 400 years ago, they built wooden slides covered with ice and people would slide down them on small sleds. In Paris they had little snow so they built wooden slides and small cars would roll down them. Although the roller coaster has advanced at a dramatic rate over the last century in which coasters have become faster, adding many twists and spins, the scenic railway at Luna Park is the simplest of all roller coasters. It is the only riding brakeman operated roller coaster in the world today, and it is the oldest continually operating roller coaster in the world

Some scenic railway data

Track	**976m**
Speed	**Up to 50 km/hr**
Duration	**About 2.5 minutes**
Weight of train	**1500 kg**

For all questions ignore air resistance and friction, take g = 9.8 ms^{-2}

Some simple physics terms:

Velocity (circle the correct answer)

1. Velocity describes the **distance/displacement** travelled over a particular time.

2. Velocity is a **scalar/vector**.

Knowing the total distance of the ride is 976m

3. Measure the time taken for the train to cover this distance. ___________ seconds

4. What is the average speed of the train in the loop? _______________ ms^{-1}

5. Convert this speed into km/hr ___________________ km/hr

6. What is the average velocity? ______________________ ms^{-1}

7. Draw a diagram showing the forces applied by the train and acting on the train when it is stationary at the station. (Hint: four forces)

Track

8. What is the material used to make this track?______________________

9. Compare the ride on the roller coaster with the metropolis

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10. What variables would affect the speed of the roller coaster train.

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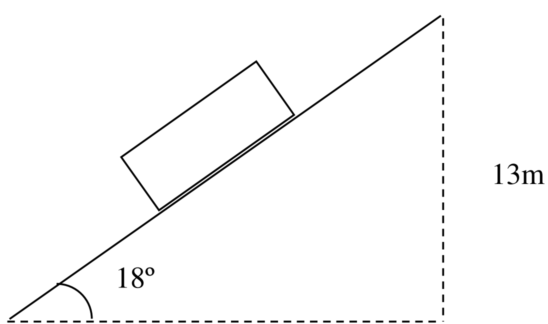
Train

The train has no engine. The train is pulled to the top of the first hill at the beginning of the ride, but after that the car must complete the ride on its own.

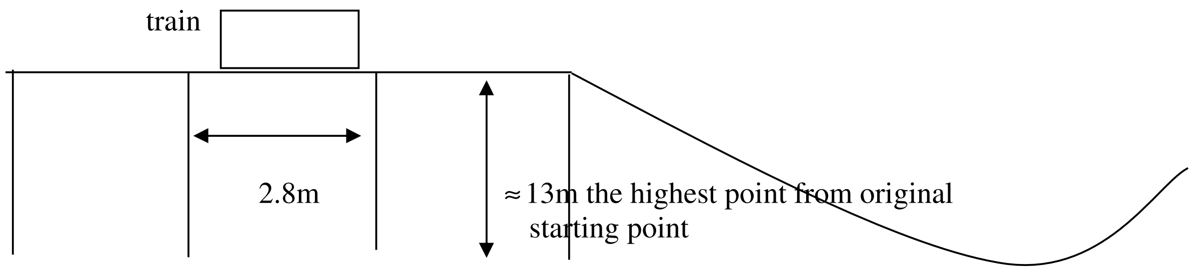
11. What single force allows the train to get back to the station once it has been let go from the first hill? ____________________________

12. On the diagram below show the forces acting on the train when it is being raised to the top of the first hill. Include the force used to bring the train up the hill and
Friction Weight Normal force



13. Draw a diagram showing the forces acting on the train when it is half way down the first hill.

14. What is the velocity of the train at the top of the first hill? The handrail spacings are approximately 2.8m apart.



Time the train across at least 2 sections (one section being 2.8m) make sure this is measured using only the horizontal section of track.

Time = ____________________ (seconds) Number of sections = ________________

Total distance = number of sections × 2.8 = _____________________m

Velocity at top = total distance ÷ time = _____________________ms^{-1}

15. What is the velocity at the bottom of the first hill?

ENERGY AT TOP	=	**ENERGY AT BOTTM**
$E_{TOT\,(TOP)}$	=	$E_{TOT\,(BOTTOM)}$
KE + PE	=	KE +PE
$\frac{1}{2}mv^2 + mgh$	=	$\frac{1}{2}mv^2 + mgh$

Masses cancel out as it is the same roller coaster at the top as the bottom (that is divide both sides by m as same mass)

$\frac{1}{2}(v_{at\ top})^2 + gh_{top}$ = $\frac{1}{2}(v_{at\ bottom})^2 + gh_{bottom}$

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16. What is the velocity at the top of the second hill?

Assume second hill ≈ 11m the highest point from original starting position

Since ignore air resistance and friction can use conservation of energy at any point of the roller coaster.

ENERGY AT TOP OF 1ST HILL	=	**ENERGY AT TOP OF 2ND HILL**
$E_{TOT\,(TOP)}$	=	$E_{TOT\,(TOP)}$
KE + PE	=	KE +PE
$\frac{1}{2}mv^2 + mgh$	=	$\frac{1}{2}mv^2 + mgh$

Masses cancel out as it is the same roller coaster at the top as the bottom (that is divide both sides by m as same mass)

$\frac{1}{2}(v_{at\ top})^2 + gh_{top}$ = $\frac{1}{2}(v_{at\ bottom})^2 + gh_{bottom}$

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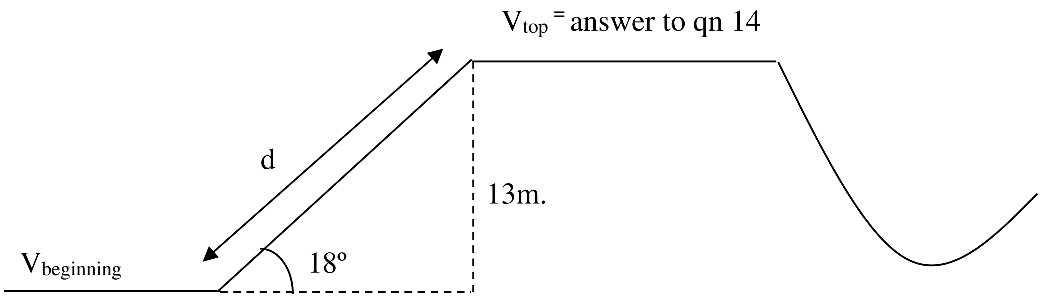
17. What is the force required for the train to be moved from the bottom of the first hill to the top of the first hill?

Work = Fd



Total energy at beginning + Work	**=**	**Total energy at top of 1st hill**
KE + PE + W	=	KE + PE
$\frac{1}{2}mv_{begining}^2 + mgh_{begining} + Fd$	=	$\frac{1}{2}mv_{top}^2 + mgh_{top}$

This time masses cannot be cancelled
Take the mass of the train to be at capacity = 3000 kg

Need to find velocity of $V_{beginning}$
Time the train across at least 2 sections (one section being 2.8m) make sure this is measured using only the horizontal section of track just before incline.

Time = ____________________ (seconds) Number of sections = _____________________

Total distance = number of sections × 2.8 = ______________________m

Velocity at beginning = total distance ÷ time = ______________________ms^{-1}

$\frac{1}{2}mv_{begining}^2 + mgh_{begining} + Fd$ = $\frac{1}{2}mv_{top}^2 + mgh_{top}$

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18. Explain what happens to your body on corners using at least one of Newton's Laws.

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19. Take note where the train attendant applies the brakes along the track.

a. How many times is the brake applied?_________________________

b. Where are the brakes applied? ____

c. Why do you think the brakes need to be applied?

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20. One side of the train has free wheels and the other side has fixed wheels. Why are fixed wheels needed? After going on the ride which side do you think the fixed wheels are on?

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Projectile Motion

When the train leaves the first hill it is travelling at (answer to question 14) **V** = _________ ms^{-1}

21. Assume the track was removed show the path it would follow using this horizontal speed.

Vertical distance down from top of hill H	Horizontal position for train $x = V\sqrt{2H/g}$
0	
2	
6	
10	
14	

22. Draw the path the train would take assuming the track was removed. Include a scale.

23. Compare the path above with the actual first hill decline.

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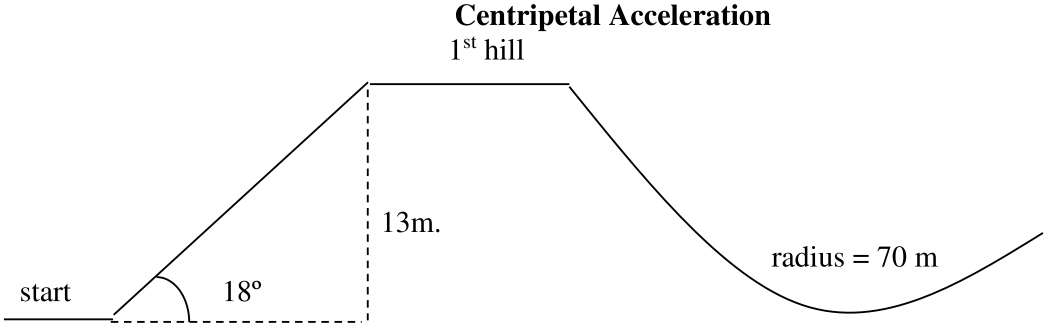
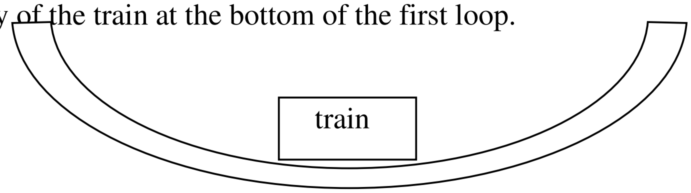
Centripetal Acceleration



24. Show the forces acting on the train, the direction of the acceleration and direction of velocity of the train at the bottom of the first loop.



25. Assume the velocity of the train at this point is the same as the velocity at the bottom of the first hill (answer in question 15). Determine the reaction force by the track on the train at this point. (Net F = ma = mv^2/r)

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