Roller Coaster Loop Lab

Vertical circular motion and the normal force

Name _____ Period _____ Date _____

Investigate how loop radius changes the normal force at the bottom. Use a linear graph to connect the force to measured speed.

Time 50 minutes • Open buildphysics.com/?experiment=vertical-circular-coaster

Model and measurements

Keep the default release point and Initial cart speed of 0 m/s. Friction is off; g = 9.8 m/s².

$$\Sigma F_r = ma_r \quad a_r = \frac{v^2}{r} \quad F_g = mg$$

r is Cart path radius, measured to the cart center. N and v are normal force and speed at the bottom.

Predict before running

With the same bottom speed, how will increasing the loop radius change the normal force? Predict and explain.

Part A Compare cart masses

1. In Explore this setup, keep Cart path radius at 4 m and Initial cart speed at 0 m/s. Test the Moving masses below. Reset between trials.
2. Run and pause just before the cart enters the loop. Use Step to reach the bottom just inside the circular section, where normal force rises.
3. Read Normal force and Speed in Explore this setup. Use this same bottom location for every trial.

Mass (kg)	Bottom v (m/s)	Bottom N (N)
0.5		
1.0		
2.0		

A1. Use two trials to compare the mass ratio and normal-force ratio. How did mass affect bottom speed?

A2. At the bottom, normal force points up and weight points down. Explain why N must exceed mg.

Part B Design and collect

Suggested time 16 minutes

Investigation question How does bottom normal force depend on loop radius when mass and release point are fixed?

Use the five supported radii from 2 to 6 m. Choose their trial order. Keep Moving mass at 1.0 kg and the cart's default release point and starting speed.

B1. Identify the independent and dependent variables.

B2. What will you keep constant? How will you do this?

B3. List your radius settings in trial order. Why does this range help reveal the relationship?

B4. How will you locate the bottom and check that bottom speed is approximately the same across trials?

B5. Write a procedure another group could follow.

Record your measurements

Moving mass = 1.0 kg Same release point Initial cart speed = 0 m/s

Trial	Radius r (m)	Bottom v (m/s)	Bottom N (N)
1			
2			
3			
4			
5			
Extra			

Part C Build and analyze a linear graph

Suggested time 14 minutes

C1. The relationship is $N = mg + \frac{mv^2}{r}$. Describe how N depends on r when m and v are fixed.

C2. Choose quantities for a straight-line graph. Label the table with your choices and units, and calculate the transformed values.

Trial	_____ Units _____	_____ Units _____
1		
2		
3		
4		
5		
Extra		

C3. Plot your transformed data and draw a best-fit line. Label both axes with quantities and units.



C4. Calculate slope and intercept with units. Use the slope to find bottom speed. Compare with measured speed and interpret the intercept.

Part D Explain and predict

Suggested time 8 minutes

D1. A student claims, “Doubling radius halves the normal force.” Evaluate this claim by distinguishing N from the inward net force.

D2. Do your line’s slope and intercept support the model? Refer to measured speed and the cart’s weight.

D3. Choose a new mass from 0.6 to 1.8 kg, different from Part A. At r = 4 m, use your fit and the mass ratio to predict N before running. Measure N and compare.

New mass (kg)	Predicted N (N)	Measured N (N)

Comparison