VERTICAL CIRCULAR MOTION

Changing speed, tension, and the condition for a taut string

Name: _____	Period: _____	Date: _____

INVESTIGATION QUESTION **How do speed and string tension vary between the bottom and top of a vertical circle?**

TIME 30 minutes	SIMULATION BuildPhysics > Vertical circular motion	UNIT 2 Force & Translational Dynamics

Learning targets

- Compare speed and tension at multiple locations in a vertical circle.
- Apply radial Newton's second law at the top and bottom.
- Find the minimum starting speed needed to keep the string taut.

Model before you measure

The baseline has m = 1.0 kg, r = 2.5 m, and a bottom speed of 14 m/s. Choose inward as the positive radial direction.	Bottom: $T - mg = mv^2/r$ Top: $T + mg = mv^2/r$

Important: Use g = 9.8 m/s². A string can pull but cannot push, so its tension cannot be negative.

Pre-lab prediction | 4 minutes

1. At which location should the object move fastest: top or bottom? Explain.

_____

2. At which location should string tension be greatest?

_____

3. What does it mean physically if a calculation predicts negative string tension?

_____

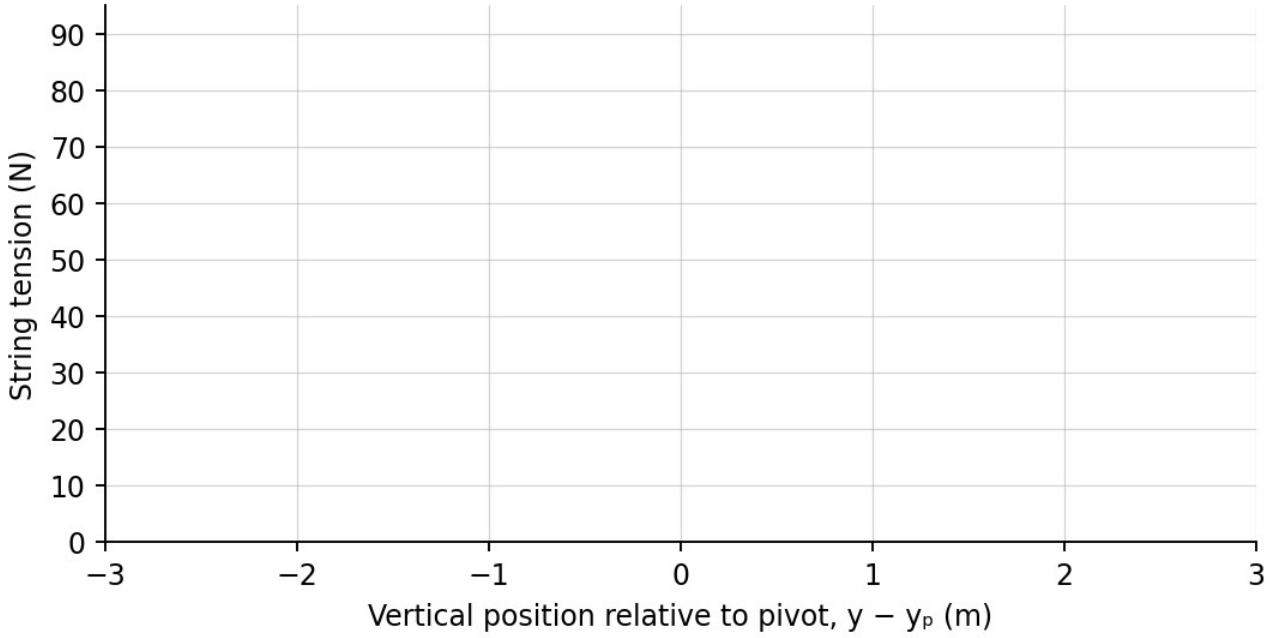
PART A Compare four locations in one complete circle

Setup | 3 minutes

- ☐ Load Vertical circular motion. Keep m = 1.0 kg, r = 2.5 m, and initial bottom speed = 14 m/s.
- ☐ Graph string tension, speed, and y-position.
- ☐ Run and pause near the bottom, right side, top, and left side.
- ☐ Record the speed and tension at each location. Repeat if needed for cleaner readings.

Data table | 10 minutes

Location	$y - y_p$ (m)	Measured speed (m/s)	Measured tension (N)
Bottom	−2.5		
Right side	0		
Top	+2.5		
Left side	0		



4. Plot tension versus vertical position using the four measurements. Sketch the trend.

PART B Lower the starting speed and test string contact

Minimum-speed test | 7 minutes

Starting condition: Return the mass to the bottom before every trial. Change only the initial horizontal speed.

Initial bottom speed (m/s)	Completes circle?	Speed near top (m/s)	Minimum tension (N)
14.0			
12.0			
11.0			
10.0			

Predicted minimum bottom speed for a taut string: v = √(5gr) = _____ m/s.

Analysis | 7 minutes

5. Why was the object faster at the bottom than at the top?

_____

6. Use radial force equations to explain why tension is greater at the bottom.

_____

7. How did the simulation indicate that the string became slack?

_____

8. Compare your experimental threshold with √(5gr).

_____

Claim-Evidence-Reasoning conclusion

Evaluate this statement: “The string tension is constant during vertical circular motion because the radius is constant.”

CLAIM	Accept, reject, or revise the statement.
EVIDENCE	Cite at least two measurements or graph features.
REASONING	Connect your evidence to the force model and Newton's laws.

Exit ticket

At the top of a vertical circle, what minimum speed is required for a string of radius r to remain just taut? Express the result using g and r.

_____

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