STATIC TORQUE BALANCE

Wall-supported beam, hinge forces, and support-rope tension

Name: _____	Period: _____	Date: _____

INVESTIGATION QUESTION **How does support-rope angle affect the tension required for rotational equilibrium?**

TIME 30 minutes	SIMULATION BuildPhysics > Static torque balance	UNIT 5 Torque & Rotational Dynamics

Learning targets

- Apply the rotational-equilibrium condition to a supported beam.
- Determine how rope angle changes the torque produced by tension.
- Interpret the slope of a transformed tension graph.

Model before you measure

Take torques about the wall hinge so the unknown hinge forces produce no torque. The beam's weight acts at its center of mass.	$\Sigma\tau_{hinge} = 0 \qquad T r_T \sin\theta = mg\, r_{cm}$

Important: Use g = 9.8 m/s². Keep beam mass, beam angle, and rope attachment point fixed in Part A.

Pre-lab prediction | 4 minutes

1. As the rope becomes more horizontal, should the required tension increase or decrease?

_____

2. What part of the tension produces torque about the hinge?

_____

3. Why is choosing the hinge as the torque axis useful?

_____

PART A Change rope angle

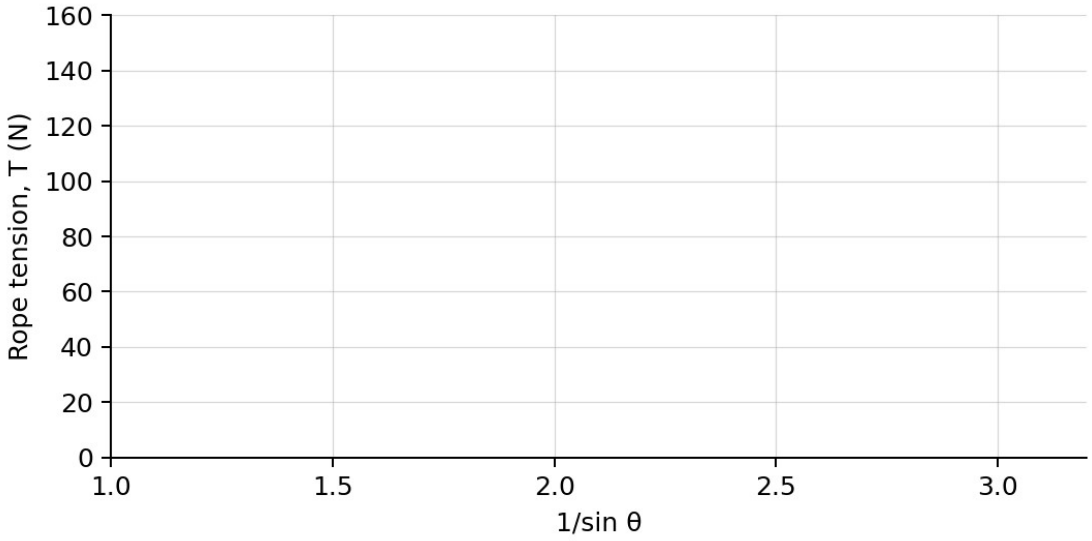
Setup | 3 minutes

- ☐ Load Static torque balance. Record beam mass, center-of-mass distance, and rope attachment distance from the hinge.
- ☐ Keep the beam fixed in its original orientation.
- ☐ Change the rope geometry to create the listed angles between the rope and the beam.
- ☐ Run briefly, pause, and record rope tension and the hinge-force components.

Angle measurement: Measure θ between the rope and the beam, not between the rope and the horizontal.

Data table | 10 minutes

Rope angle θ	sin θ	1/sin θ	Measured tension T (N)	Calculated T (N)	Hinge-force magnitude (N)
20°					
30°					
40°					
50°					
60°					



4. Plot measured rope tension versus 1/sin θ. Draw a best-fit line.

PART B Change beam mass

Mass test | 7 minutes

Fixed geometry: Choose one rope angle from Part A and keep all distances and angles constant.

Beam mass (kg)	Beam weight (N)	Measured tension (N)	T / m (N/kg)
2.0			
4.0			
6.0			
8.0			

Analysis | 7 minutes

5. Why did tension increase as the rope became more horizontal?

6. What physical combination should the slope of the T-versus-1/sin θ graph represent?

7. How did beam mass affect rope tension at fixed geometry?

8. Why do the hinge forces not appear in the torque equation about the hinge?

Claim-Evidence-Reasoning conclusion

Evaluate this claim: A support rope produces the same torque whenever its tension is unchanged.

CLAIM	Accept, reject, or revise the statement.
EVIDENCE	Cite at least two measured trials or graph features.
REASONING	Use the perpendicular component of tension, the lever arm, and $\Sigma\tau = 0$.

Exit ticket

A rope attached to a beam is moved to a smaller angle while all other variables stay fixed. Predict what happens to the required tension.