

MCQ Part 1

1. A uniform horizontal beam of mass M and length L is attached to a wall by a frictionless hinge at its left end. A cable connects the right end of the beam to the wall at a point directly above the hinge, making an angle θ with the beam. Which of the following correctly gives the tension T in the cable?

- (a) $T = \frac{Mg}{2 \sin \theta}$
 (b) $T = \frac{Mg}{2 \cos \theta}$
 (c) $T = \frac{Mg \sin \theta}{2}$
 (d) $T = \frac{Mg}{\sin \theta}$
 (e) $T = Mg \cos \theta$

2. A uniform ladder of weight W and length L leans against a frictionless wall, making an angle θ with the floor. The floor exerts both a normal force and a friction force on the base of the ladder. Which of the following correctly describes the conditions for the ladder to be in static equilibrium?

	Normal force from floor	Friction force from floor
(A)	$N = W$	$f = 0$
(B)	$N = W$	$f = \frac{W}{2 \tan \theta}$
(C)	$N = W \cos \theta$	$f = W \sin \theta$
(D)	$N = W$	$f = \frac{W \cos \theta}{2 \sin \theta}$
(E)	$N = W \sin \theta$	$f = W \cos \theta$

3. A non-uniform plank of length 2.0 m and weight 80 N is supported at its two ends by scales. The left scale reads 50 N and the right scale reads 30 N. How far from the left end is the center of gravity of the plank?

- (a) 0.55 m
 (b) 0.60 m
 (c) 0.75 m
 (d) 0.80 m
 (e) 1.00 m

4. A uniform rod of mass m and length L is pivoted at one end and held horizontal by a vertical force F applied at the free end, and by a pin force at the pivot. If the vertical force F is instead applied at the midpoint of the rod, by what factor does F change to maintain equilibrium?

- (a) F is halved.
 (b) F doubles.

- (c) F is unchanged.
- (d) F increases by a factor of $\frac{3}{2}$.
- (e) F decreases by a factor of $\frac{2}{3}$.

MCQ Part 2

A uniform horizontal beam of mass $m = 20.0\text{ kg}$ and length $L = 4.0\text{ m}$ is hinged to a wall at its left end. A cable attached to the wall supports the beam at a point $\frac{3L}{4}$ from the hinge, making an angle of 30° above the horizontal. A crate of mass $M = 30.0\text{ kg}$ hangs from the right end of the beam.

5. What is the tension in the cable?
 - (a) 196 N
 - (b) 272 N
 - (c) 388 N
 - (d) 457 N
 - (e) 523 N

6. What is the magnitude of the vertical component of the hinge force?
 - (a) 22 N upward
 - (b) 22 N downward
 - (c) 197 N upward
 - (d) 197 N downward
 - (e) 294 N upward

7. If the cable were instead attached at the very end of the beam (at L from the hinge) at the same 30° angle, the tension in the cable would:
 - (a) Increase, because the cable is farther from the hinge.
 - (b) Decrease, because the lever arm of the cable increases.
 - (c) Remain the same, since the angle is unchanged.
 - (d) Decrease by a factor of $\frac{3}{4}$.
 - (e) Increase by a factor of $\frac{4}{3}$.

Free Response

8. A uniform plank of mass $m = 15.0\text{ kg}$ and length $L = 3.00\text{ m}$ is supported by a fulcrum placed 1.00 m from the left end. A child of mass $m_1 = 25.0\text{ kg}$ sits at the left end, and an adult of mass m_2 sits at the right end.

- (a) Find the mass m_2 required to keep the plank in static equilibrium. Take torques about the fulcrum.
- (b) Find the normal force exerted by the fulcrum on the plank.
- (c) The adult moves 0.50 m to the left (closer to the fulcrum). What mass m'_2 would now be needed at the right end for a different person to maintain equilibrium? Show your work clearly.
- (d) If the plank were non-uniform and its center of gravity were located 1.60 m from the left end (instead of at the midpoint), how would the required mass m_2 in part (a) change? Calculate the new value.
9. A uniform ladder of mass $m = 12.0$ kg and length $L = 5.00$ m leans against a smooth (frictionless) vertical wall. The base of the ladder rests on a rough horizontal floor and makes an angle of $\theta = 60.0^\circ$ with the floor. A painter of mass $M = 70.0$ kg stands three-quarters of the way up the ladder.
- (a) Draw a free body diagram of the ladder. Label all forces and their points of application.
- (b) Find the normal force from the wall on the top of the ladder.
- (c) Find the normal force and friction force exerted by the floor on the base of the ladder.
- (d) Find the minimum coefficient of static friction μ_s between the ladder and the floor needed to prevent slipping.
- (e) If the painter climbs higher, explain qualitatively why the ladder becomes more likely to slip, and identify which torque balance changes.
10. A uniform diving board of mass $m = 25.0$ kg and length $L = 4.00$ m is supported by two supports. Support A is at the left end and Support B is 1.50 m from the left end. A diver of mass $M = 65.0$ kg stands at the right end of the board.
- (a) Find the forces exerted by Support A and Support B on the board. Indicate the direction (up or down) of each force.
- (b) Explain why one of the support forces must be directed downward. Which physical constraint requires this?
- (c) If the diver moves to a position x from the right end, derive an expression for the force at Support A as a function of x . For what value of x does Support A exert zero force?
- (d) At what position x from the right end does the board become on the verge of tipping (i.e., Support A lifts off)? What is the force at Support B at that moment?