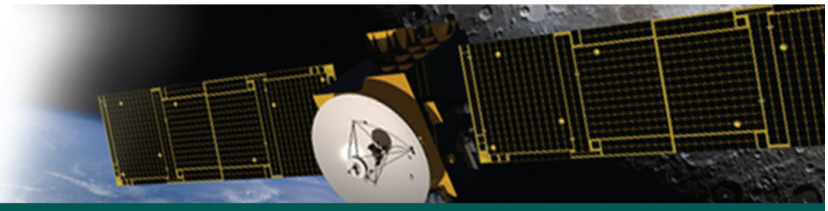


Set 3: Circular Motion

14. A string just supports a hanging brick without breaking. Explain why the string breaks if you set the brick swinging.

15. (a) Estimate the minimum speed required to spin a bucket of water at arms' length in a vertical loop without spilling the water.

(b) Explain why the water does not fall out if the bucket traverses the top of its path at this or greater speed.

(c) Does the bucket travel at a constant speed throughout its circular path? Explain.

16. A pilot flies her aeroplane in a vertical loop of diameter 1.60 km.

(a) How fast is the aeroplane travelling at the top of the loop if the pilot feels no force from either the seat or the straps?

The pilot cuts the engine at the top of the loop.

(b) Ignoring air resistance, what is the speed of the aeroplane as it emerges from the bottom of the loop?

17. An aeroplane flies in a vertical loop of radius 650 m. At the top of the loop, the pilot experiences a downward reaction force, from her the seat, equal to one fifth of her weight. Calculate the aeroplane's speed at this instant.

18. A model car of mass 2.00 kg moves in a vertical circle of radius 5.00 m. If its speed at the lowest point is 20.0 m s^{-1} and at the highest is 10.0 m s^{-1}, calculate

(a) the force that the track exerts on the car at the lowest point;

(b) the force that the track exerts on the car at the highest point.

19. You strap into a safety harness and take a roller coaster ride. In one part of the ride, the roller coaster car goes through a vertical loop at a speed of 14.0 m s^{-1}.

(a) Calculate the radius of the loop of track if you feel "weightless" as you pass through the top of the loop.

(b) Describe what would happen to you if the car went through the loop *faster* than 14.0 m s^{-1}. Explain your answer.

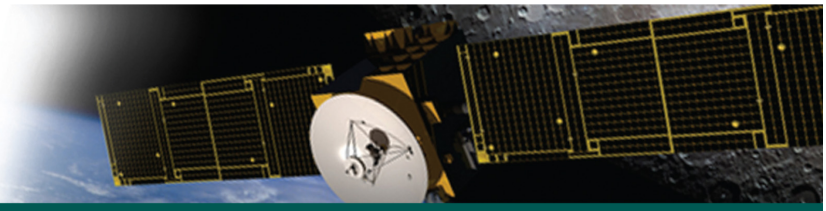
(c) Describe what would happen to you if the car went through the loop *slower* than 14.0 m s^{-1}. Explain your answer.

20. As a 40.0 kg gymnast swings in a vertical circle on a high bar, her centre of mass moves around 0.90 m from the bar.

(a) At the highest point her centre of mass is moving at 1.00 m s^{-1}. Sketch a free body diagram for this situation.

(b) How fast is she moving when her centre of mass is level with the bar? Sketch a free body diagram for this situation.

(c) How much force must she exert on the bar in order to hang on as she passes through the lowest point of her swing? Sketch a free body diagram for this situation.



21. Passengers on a fairground ride revolve at a constant speed in a vertical circle of radius 3.60 m. The ride operator has a choice of two speeds, LOW and HIGH. At the HIGH setting, passengers feel weightless at the top of the circle; at the LOW setting, the passengers revolve at half the HIGH speed.

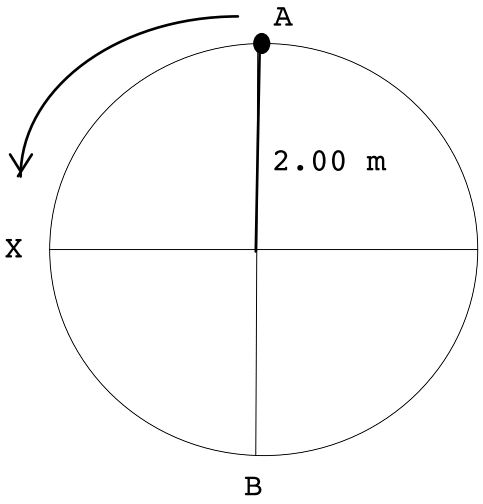
(a) Draw free body diagrams showing the forces acting on a passenger at the top and at the bottom, at each speed setting. (That's four diagrams altogether.)

(b) Calculate the speed at which the ride moves, at the HIGH setting.

(c) Calculate the reaction forces acting on a passenger of mass 60.0 kg at the top and bottom of the circle, when travelling at the HIGH setting.

(d) Calculate the reaction forces acting on a passenger of mass 60.0 kg at the top and bottom of the circle, when travelling at the LOW setting.

22. A stone of mass 2.50 kg is whirled in a vertical circle at the end of a 2.00 m length of string.



(a) The stone passes through point X at a speed of 10.4 m s^{-1}. Calculate its speed at points A and B.

(b) Calculate the tension in the string at points A and B.

(c) At which point, A, B or X, is the string most likely to break? Explain your answer.