

The background features a dark blue gradient with a starry pattern. On the left side, there are several circular diagrams illustrating motion. A large scale with numerical markings from 140 to 260 is visible. Various circles and arcs are shown with arrows indicating direction, some solid and some dashed, representing different aspects of circular motion.

CIRCULAR MOTION

PES 1000 – PHYSICS IN EVERYDAY LIFE

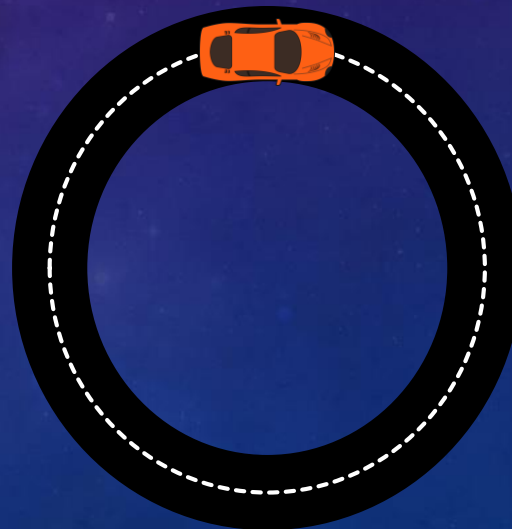
UNIFORM CIRCULAR MOTION

- For an object moving on a circle at constant speed
 - The **speed is constant**, but the **direction is not**
- Acceleration is a change in velocity, but speed is constant
 - The change in velocity is only in its direction
 - Therefore, the **acceleration is toward the center (centripetal)**
- '**Centripetal Force**' is a label for whatever force is causing the path to curve
- If the centripetal force is removed, the ball travels in a straight line **tangent to the circle** at the point of release



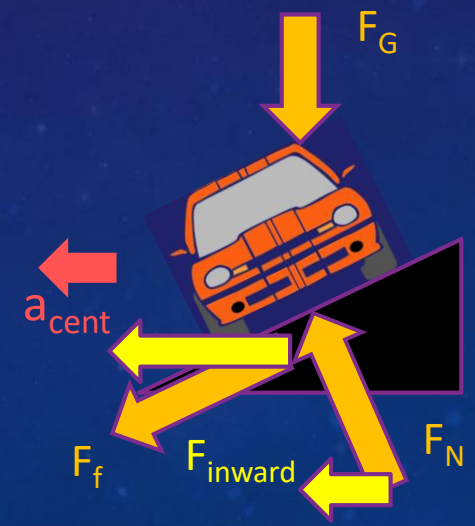
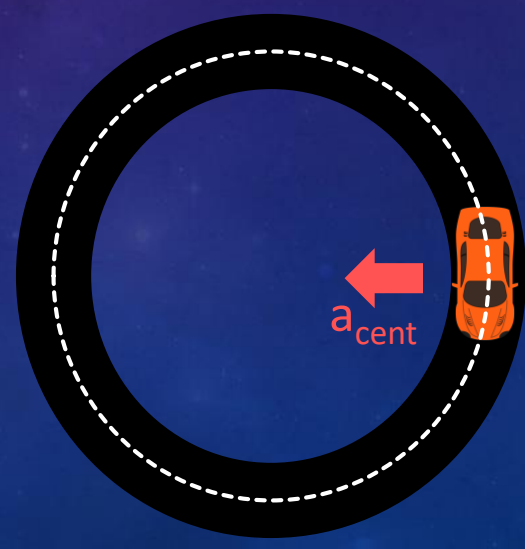
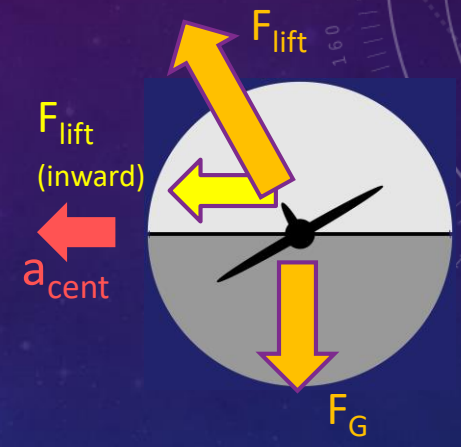
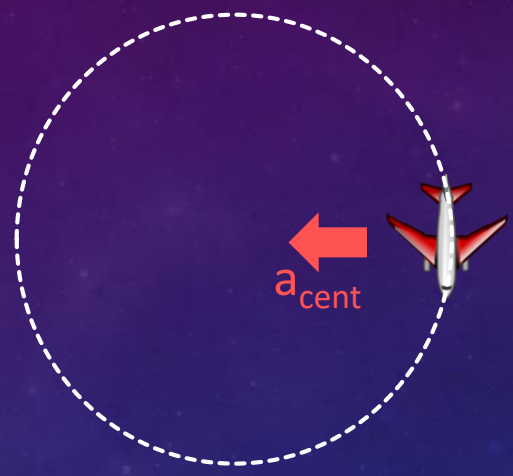
EXAMPLES

- Ball on a string
 - Centripetal force is from the **string**
- Moon in orbit
 - Centripetal force is from **gravity**
- Car on a flat, circular road
 - Centripetal force is from **friction** of tires on the road
- Airplane on a circular path
 - Centripetal force is from **part of the lift** when the plane banks into the turn



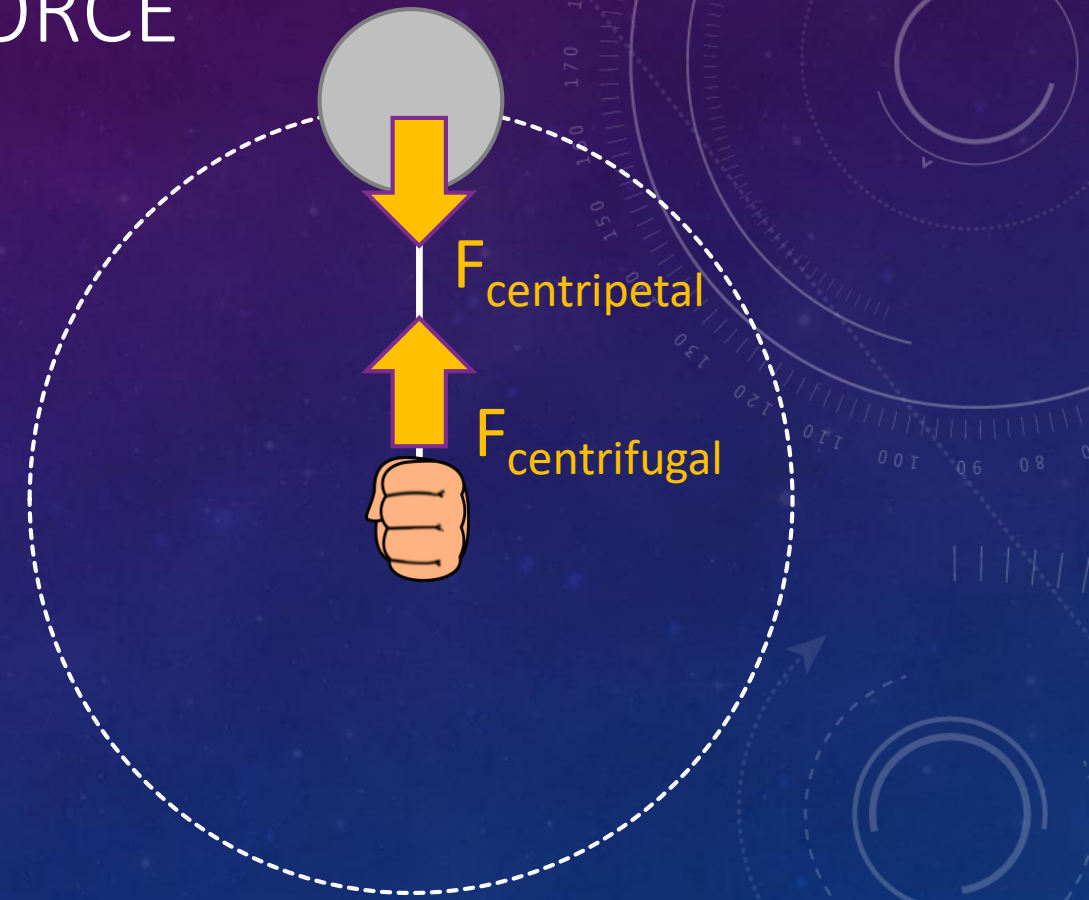
BANKING PLANE OR BANKED ROAD

- The airplane must bank inward toward the center of its turn
 - The force of lift tilts inward
 - The inward part of the lift is 'centripetal'
 - It is the cause of the inward acceleration
- The road is banked inward toward the center of the curving road
 - Part of the normal force is inward
 - Part of the friction is also inward
 - The sum of these parts is 'centripetal'
 - They are the cause of the inward acceleration



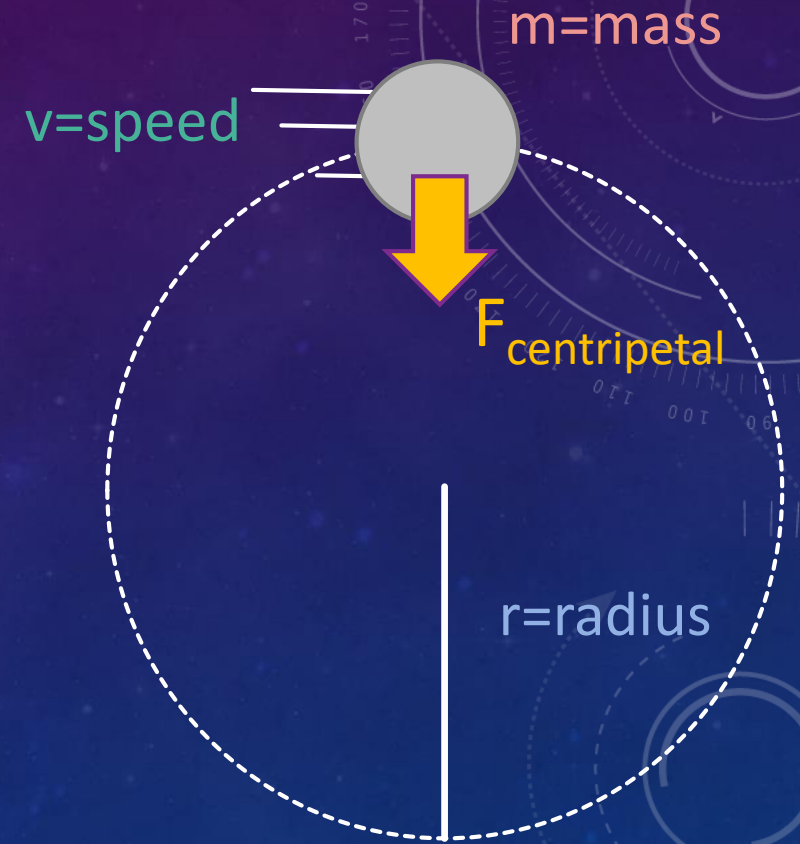
CENTRIPETAL VS. CENTRIFUGAL FORCE

- **Centripetal force:**
 - Acts **on the ball**
 - Acts **inward**
- **Centrifugal force:**
 - Acts **on the string holder**
 - Acts **outward** ('fugal' means 'to flee')
 - It is the equal and opposite reaction (Newton's Third Law) to the centripetal force
 - It is felt because of the inertia of the ball which opposed the inward acceleration



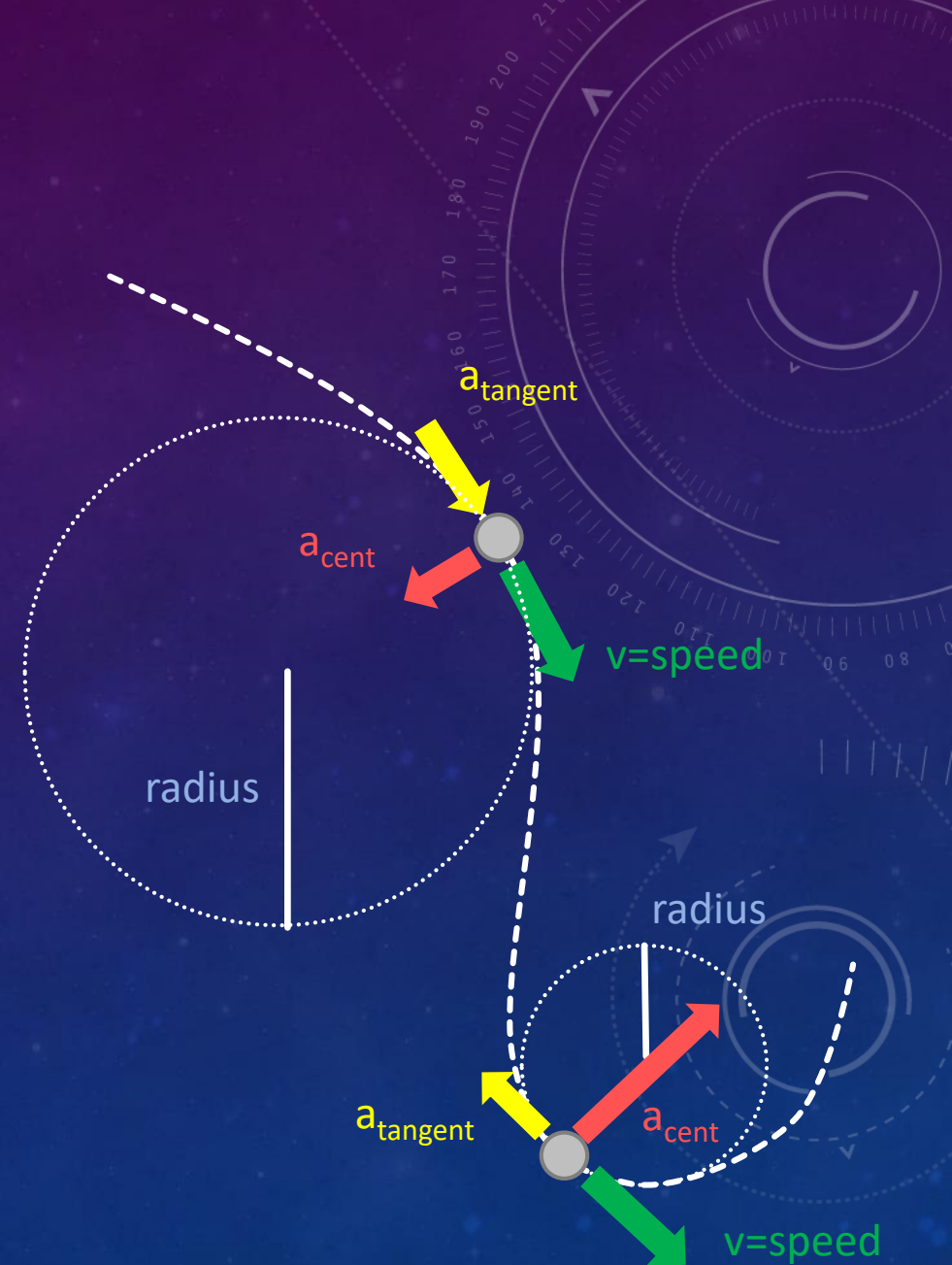
WHAT DOES CENTRIPETAL FORCE DEPEND ON?

- The **centripetal force** depends on:
 - The **mass** of the turning object – more mass requires more force
 - The **speed** of the turning object – A faster object requires more force
 - The **radius** of the curved path – The smaller the circle, the more force is required
- The formula to find the force is this:
 - $F_{\text{cent}} = m * v^2 / r$



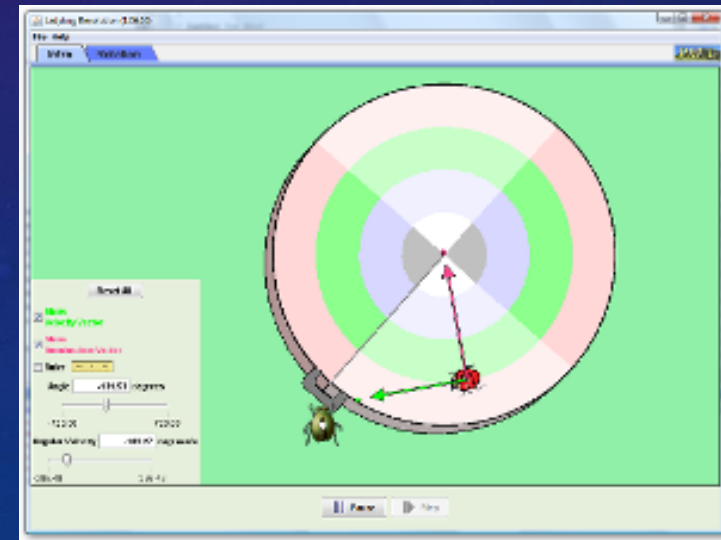
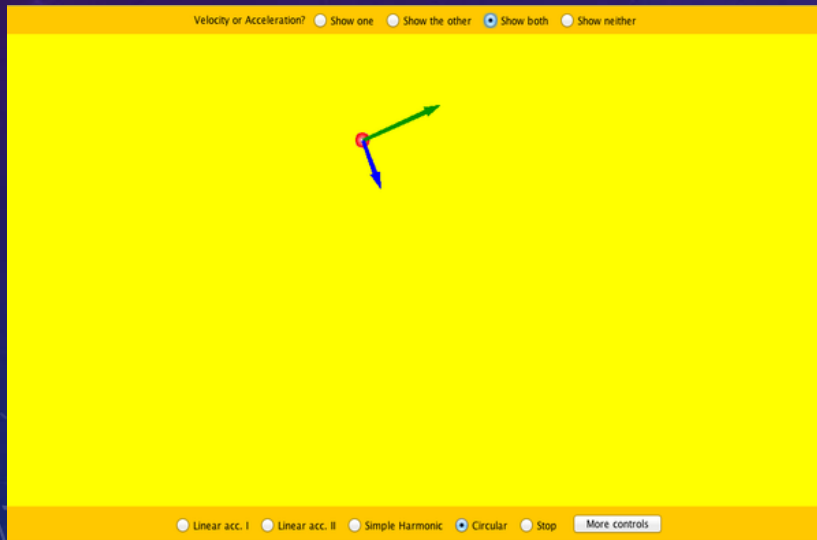
GENERAL CURVILINEAR MOTION

- So far, we have examined motion in 1-D along a line, and motion with uniform speed in a circle
- If the motion is more complicated, we just look at a moment in time as the object moves along a **curvilinear path** with varying speed. At this instant:
 - You can draw a circle that just touches the curve.
 - **Uniform circular motion** describes the circular motion around this circle at the speed at this instant. Part of the total acceleration is centripetal.
 - **Motion in 1-D** describes the motion along the path. The rest of the total acceleration is along the path (tangent)
- You can do this at any point along the path



SIMULATIONS

- The '2-D Motion' and 'Ladybug Revolution' simulations let you experiment with circular motion
- The can be found here:
 - <https://phet.colorado.edu/en/simulation/legacy/motion-2d>
 - <https://phet.colorado.edu/en/simulation/legacy/rotation>
- Let's play with the simulations:



CONCLUSIONS

- **Uniform Circular Motion** describes motion on a circle at constant speed
- Since velocity is changing direction, there must be force and therefore **acceleration toward the center**
- **Centripetal force** is the central force on the turning object and **centrifugal force** is the reaction force on the object causing the turning
- Many types of forces can be centripetal
- Combining **motion in 1-D** and **uniform circular motion** can describe more **general types of motion**