Physic² 121:
Phundament°ls of Phy²ics I

November 3, 2006

Announcement: WebAssign Bug

- There is an error in the WebAssign solution to problem 8 in HW 8
  - The error only affects the first part of the problem
  - It will not affect you if the mass of the heavier object is 3*m*
  - If the mass of the heavier object is 2*m*, 4*m*, or 5*m*, it will mark your answer to the first part as wrong even if it is correct
  - The last two parts are not affected.
  - I will go in by hand and check your answer to the first part and give credit if it is correct. So please go ahead and do the problem anyway.

Chapter 7

Rotational Motion

From Last Time

- Angular velocity

$$\omega = \frac{\Delta\theta}{\Delta t}$$

- Angular Acceleration

$$\alpha = \frac{\Delta\omega}{\Delta t}$$

- Angular equations of motion (constant angular acceleration)

$$\omega = \omega_i + \alpha t$$

$$\Delta\theta = \omega_i t + \tfrac{1}{2}\alpha t^2$$

- Relationship to linear motion quantities
  - Subscript "t" refers to tangential motion

$$s = r\theta$$

$$v_t = r\omega$$

$$a_t = r\alpha$$

Example Problem (7.5)

- A dentist's drill starts from rest. After 3.20 s of constant angular acceleration, it turns at a rate of 2.51×10^4 rev/min.
  a) Find the drill's angular acceleration
  b) Determine the angle (in radians) through which the drill rotates during this time.

Example Problem (7.9)

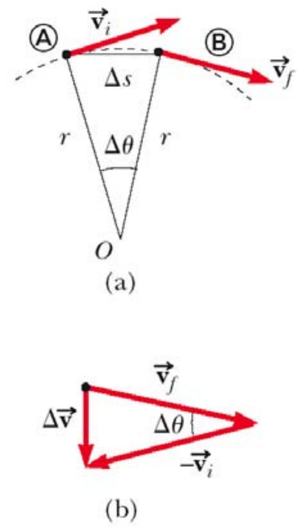
- The diameter of the main rotor and tail rotor of a helicopter are 7.60 m and 1.02 m, respectively. The respective rotational speeds are 450 rev/min and 4,138 rev/min.
  - Calculate the speeds of the tips of both rotors.
  - Compare to the speed of sound, 343 m/s.

Centripetal Acceleration

- An object traveling in a circle, even if it moves with a constant speed, will have an acceleration
- The centripetal acceleration is due to the change in the *direction* of the velocity

Centripetal Acceleration, cont.

- Centripetal refers to "center-seeking"
- The direction of the velocity changes
- The acceleration is directed toward the center of the circle of motion



Centripetal Acceleration, final

- The magnitude of the centripetal acceleration is given by

$$a_c = \frac{v^2}{r}$$

  - This direction is toward the center of the circle

Centripetal Acceleration and Angular Velocity

- The angular velocity and the linear velocity are related ($v = \omega r$)
- The centripetal acceleration can also be related to the angular velocity

$$a_C = \omega^2 r$$

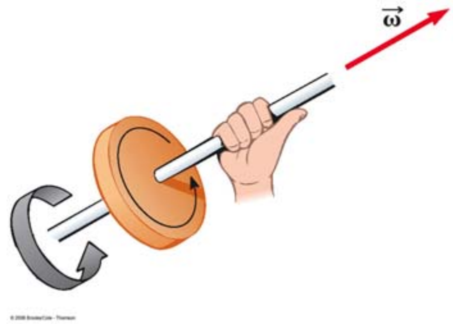
Total Acceleration

- The tangential component of the acceleration is due to changing speed
- The centripetal component of the acceleration is due to changing direction
- Total acceleration can be found from these components

$$a = \sqrt{a_t^2 + a_C^2}$$

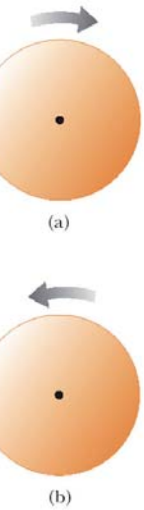
Vector Nature of Angular Quantities

- Angular displacement, velocity and acceleration are all vector quantities
- Direction can be more completely defined by using the right hand rule
  - Grasp the axis of rotation with your right hand
  - Wrap your fingers in the direction of rotation
  - Your thumb points in the direction of ω



Velocity Directions, Example

- In a, the disk rotates clockwise, the velocity is into the page
- In b, the disk rotates counterclockwise, the velocity is out of the page



Acceleration Directions

- If the angular acceleration and the angular velocity are in the same direction, the angular speed will increase with time
- If the angular acceleration and the angular velocity are in opposite directions, the angular speed will decrease with time

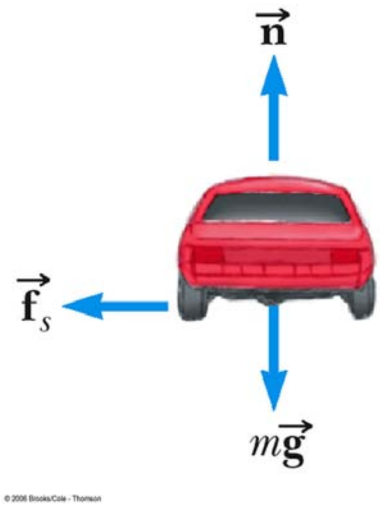
Forces Causing Centripetal Acceleration

- Newton's Second Law says that the centripetal acceleration is accompanied by a force
  - $F_C = ma_C$
  - F_C stands for any force that keeps an object following a circular path
    - Tension in a string
    - Gravity
    - Force of friction

Level Curves

- Friction is the force that produces the centripetal acceleration
- Can find the frictional force, μ, or v

$$v = \sqrt{\mu r g}$$

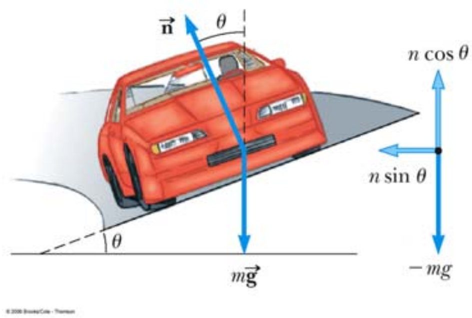


Banked Curves

- A component of the normal force adds to the frictional force to allow higher speeds

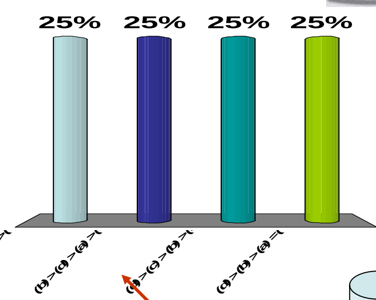
$$\tan\theta = \frac{v^2}{rg}$$

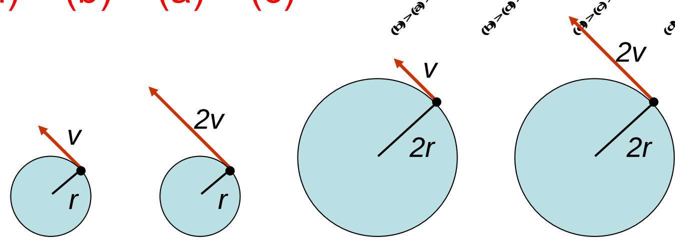
$$or\ \ a_c = g\tan\theta$$



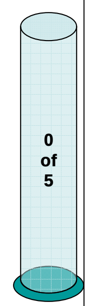
? Rank in order, from largest to smallest, the centripetal accelerations of the particles shown below

1. (b) > (a) > (d) > (c)
2. (b) > (d) > (a) > (c)
3. (d) > (c) > (b) > (a)
4. (d) > (b) > (a) = (c)





(a) (b) (c) (d)



1	2	3	4	5															