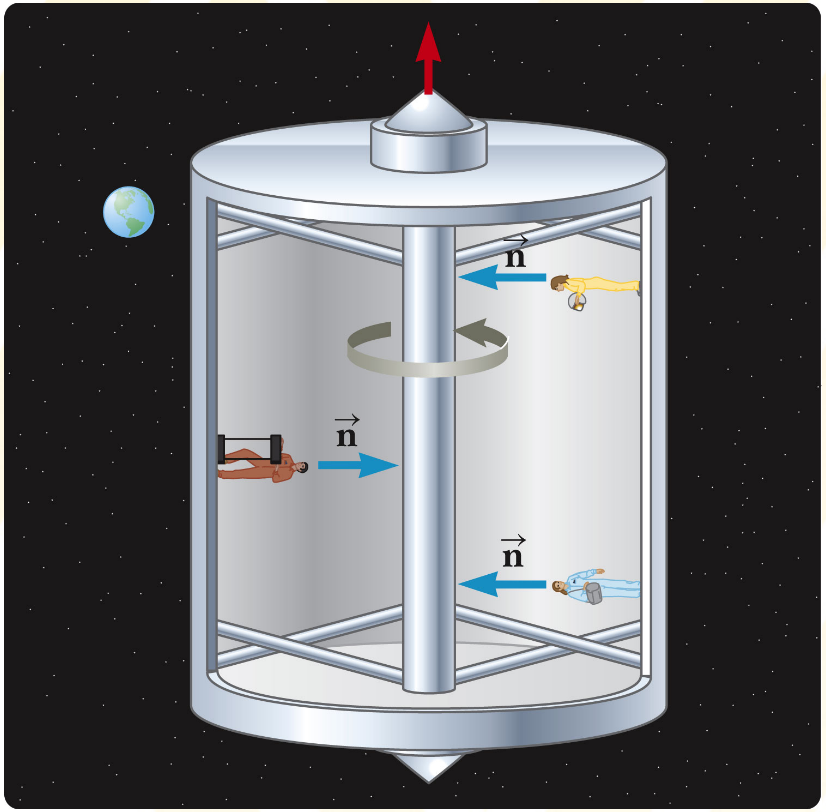
Artificial gravity

In space stations, artificial gravity can be created by rotating the entire station.

Any astronaut in the station will then experience a centripetal force exerted on him/her by the inner walls of the station (normal force).

This is useful for long stays in space to avoid weakening of muscles.

It works similarly to gravitation on earth, where any object would continue moving straight, if gravity did not cause a centripetal force on us to keep us at the surface.



Example problem: Loop the Loop

A roller-coaster car is moving around a circular loop of radius R.

(a) What speed must the car have so that it will just make it over the loop?

(b) From what height must the car initially be released (from rest) in order to make it over the loop?

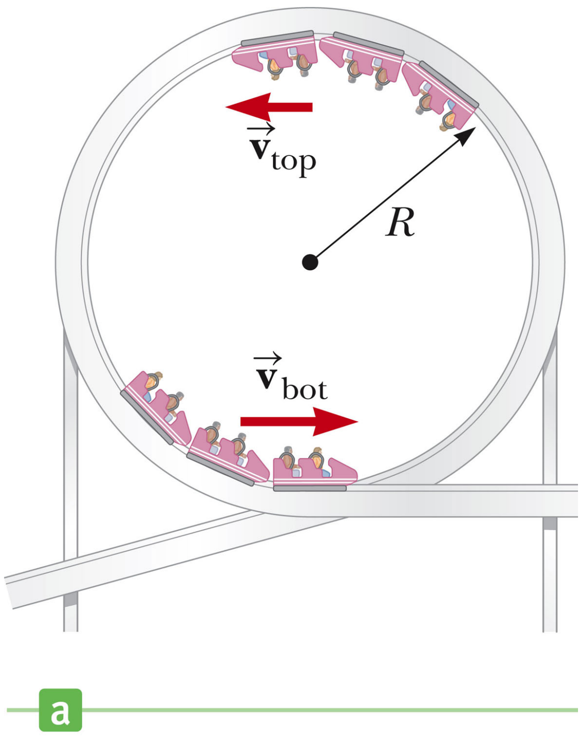


Fig. 7-15a, p. 213

Clicker question

Conversion from degree to rad:

What is $\theta = 90$ deg in radians?

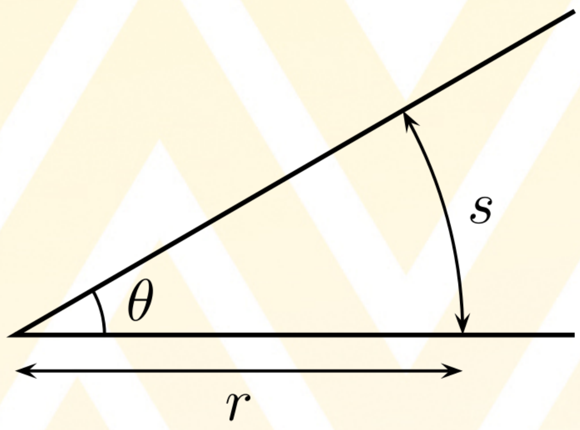
A) $\pi/4$

B) $\pi/2$

C) π

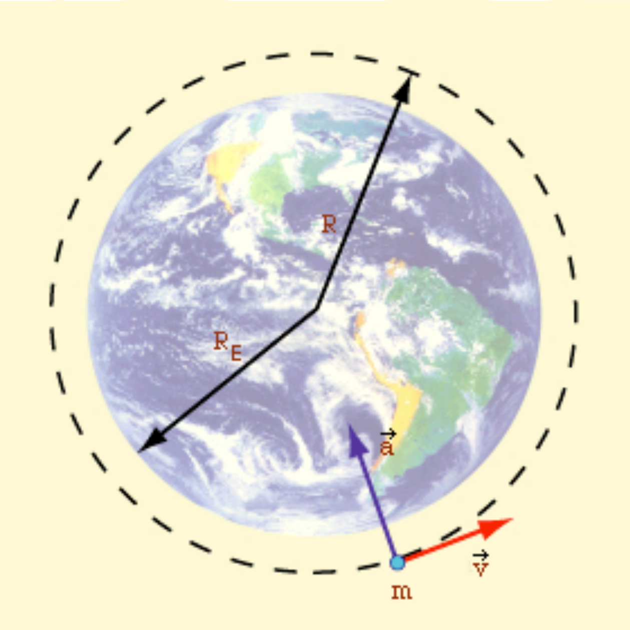
D) $3\pi/2$

E) 2π



Why does the Moon orbit the Earth?

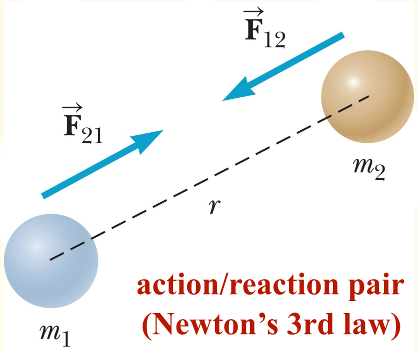
The Moon orbits the earth, because it is attracted by earth due to the gravitational force, which acts as the centripetal force on the Moon.



Gravitational Force: If two particles with masses m_1 and m_2 are separated by a distance r, an attractive force will act along a line joining them with magnitude:

$$\boxed{F = G\frac{m_1 m_2}{r^2}}$$

Here, G is "Newton's constant of gravitation" ($G = 6.673 \times 10^{-11}$ N m^2 kg^{-2}).



The Moon also attracts earth and causes ocean tides.

Clicker question

A planet has two moons with identical mass.
Moon 1 is in a circular orbit of radius r.
Moon 2 is in a circular orbit of radius 2r.

The magnitude of the gravitational force exerted by the planet on Moon 2 is

A) Four times as large

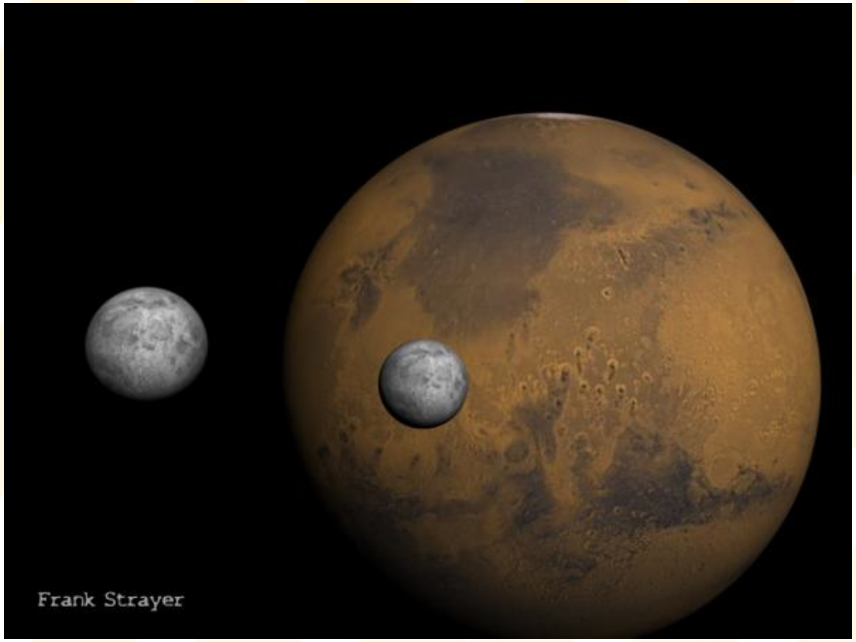
B) Twice as large

C) the same

D) half as large

E) one-fourth as large

as the gravitational force exerted by the planet on Moon 1.

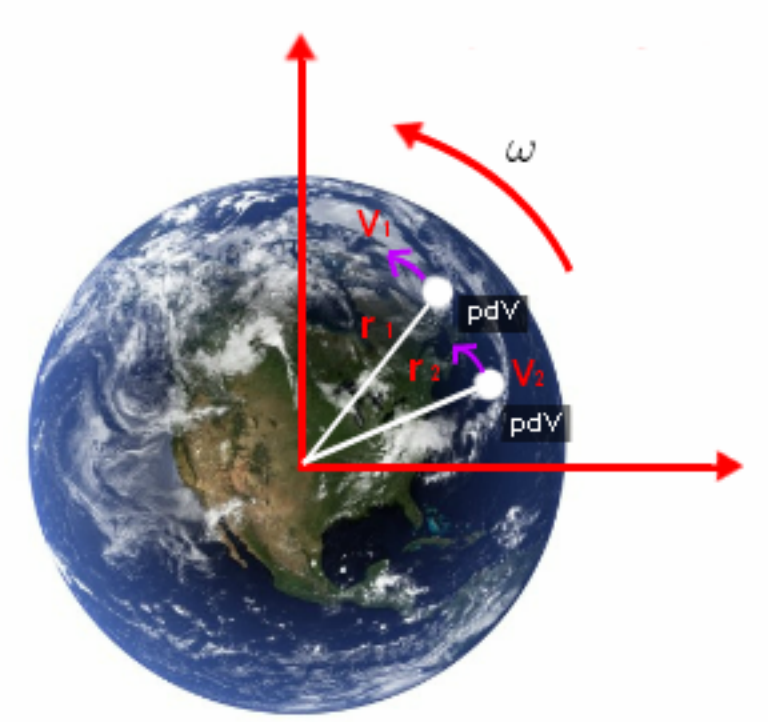


$$F = G\frac{m_1 m_2}{r^2}$$

Example problem: Angular velocity

Find the angular speed of Earth's rotation about its axis.

$$\omega_{av} = \frac{\theta_f - \theta_i}{t_f - t_i} = \frac{\Delta\theta}{\Delta t}$$



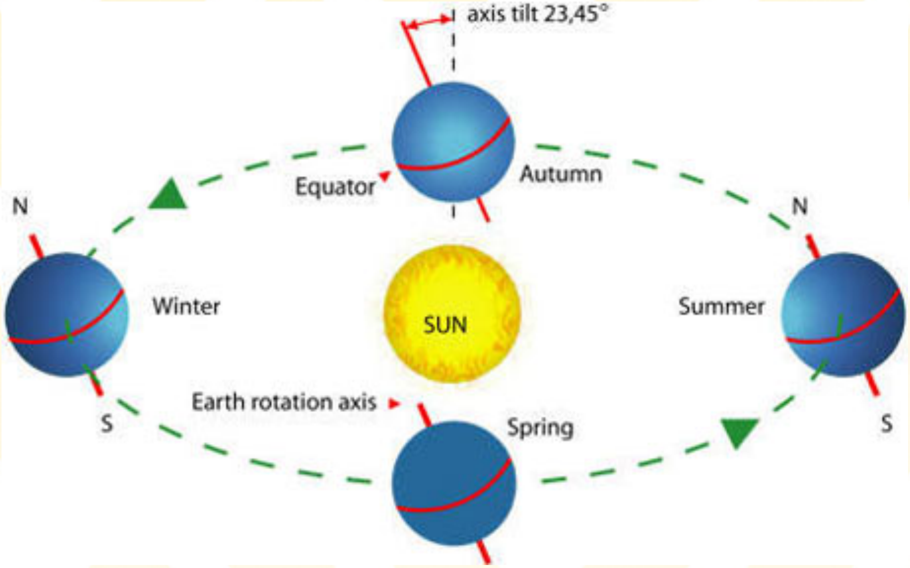
Example problem: Tangential velocity

Estimate the speed of the Earth relative to the Sun in m/s.

The distance between Earth and Sun is approximately 150 million km.

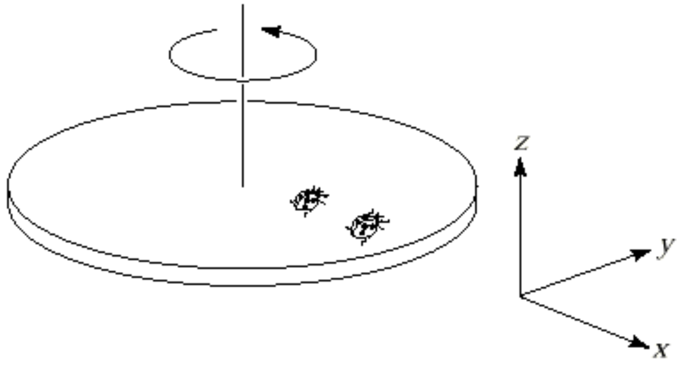
$$v_t = \omega r$$

$$\omega = 2\pi f$$



Clicker question

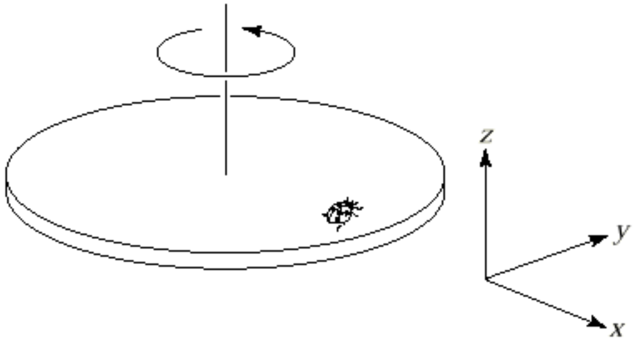
A ladybug sits at the outer edge of a merry-go-round, and a gentleman bug sits halfway between her and the axis of rotation. The merry-go-round makes a complete revolution once each second. The gentleman bug's angular speed is



(a) half the ladybug's.
(b) the same as the ladybug's.
(c) twice the ladybug's.
(d) impossible to determine

Clicker question

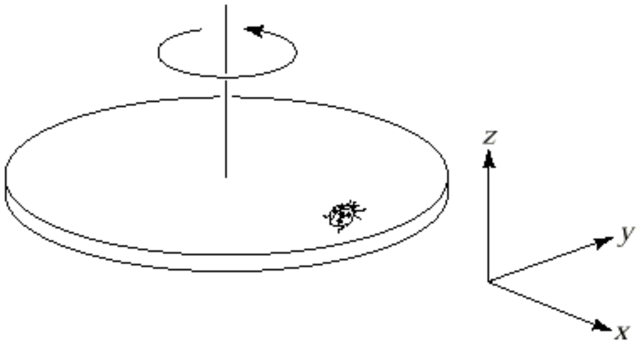
A ladybug sits at the outer edge of a merry-go-round, that is turning and slowing down. At the instant shown in the figure, the radial component of the ladybug's (Cartesian) acceleration is



(a) in the $+x$ direction.
(b) in the $-x$ direction.
(c) in the $+y$ direction.
(d) in the $-y$ direction.
(e) in the $+z$ direction.

Clicker question

A ladybug sits at the outer edge of a merry-go-round that is turning and slowing down. The tangential component of the ladybug's (Cartesian) acceleration is



A. in the $+x$ direction.
B. in the $-x$ direction.
C. in the $+y$ direction.
D. in the $-y$ direction.
E. in the $+z$ direction.

Example problem: Wheel of Fortune

Amy is on the Wheel of Fortune and has to spin the wheel. She gives the wheel an initial angular speed of 3.40 rad/s. It then rotates through 1.25 revolutions and comes to rest on BANKRUPT.

(a) Find the wheel's angular acceleration, assuming it is constant.

(b) How long does it take for the wheel to stop?

$$\theta(t) = \theta_i + \omega_i t + \frac{1}{2}\alpha t^2$$

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

Clicker question

A student sees the following question on an exam:

A flywheel with mass 120 kg, and radius 0.6 m, starting at rest, has an angular acceleration of 0.1 rad/s^2. How many revolutions has the wheel undergone after 10 s? Which formula should the student use to answer the question?

A. $\omega = \omega_o + \alpha t$

B. $\Delta\theta = \omega_o t + \frac{1}{2}\alpha t^2$

C. $\omega^2 = \omega_0^2 + 2\alpha\,\Delta\theta$

Example problem: Centrifuge

A sample of blood is placed in a centrifuge of radius 16.0 cm. The mass of a red blood cell is 3.0 10^{-16} kg, and the magnitude of the force acting on it as it settles out of the plasma is 4.0 10^{-11} N.

At how many revolutions per second should the centrifuge be operated?

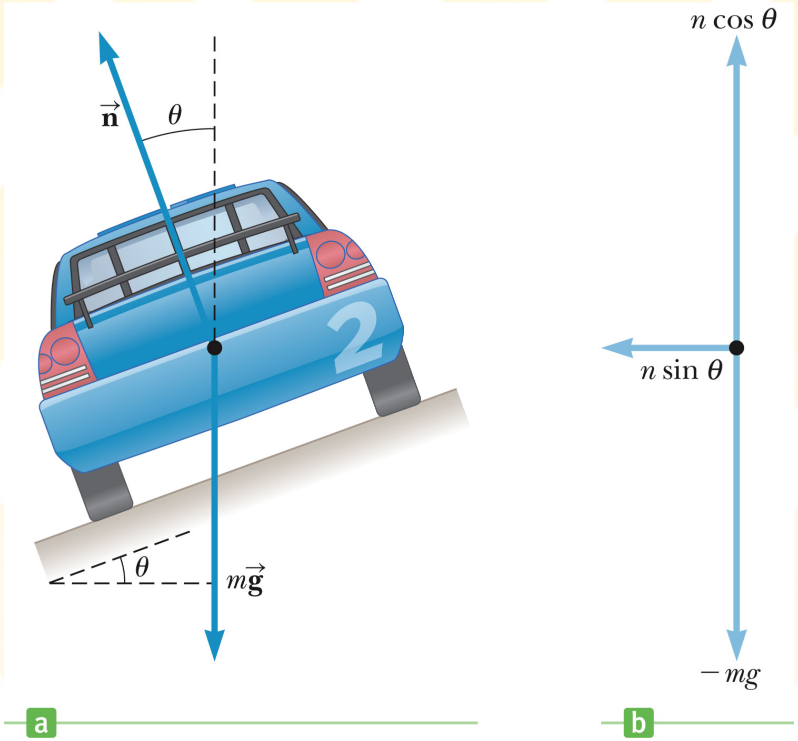
$$F_c = ma_c = m\frac{v^2}{r} = mr\omega^2$$

Example problem: Daytona 500

The Daytona International Speedway is famous for its races. Both of its curves feature four-story, 31 degree banked curves, with maximum radius of 316 m. If a car negotiates the curve too slowly, it will slip down the incline. If it is going too fast, it will slide up the incline.

(a) Find the necessary centripetal acceleration in these curves so that the car won't slip down or slide up.

(b) Calculate the speed of the race car.



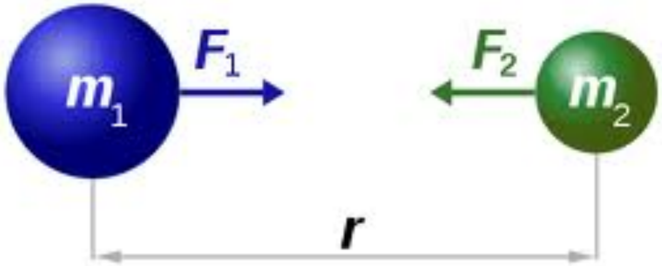
Example problem: Gravitation

We are all attracted to each other

Hannah and Tommy are sitting side by side. The distance between them is 0.5 m. Hannah weighs 50 kg and Tommy weighs 70 kg.

Estimate the force of gravitational attraction between them.

Why don't they move towards each other?



$$F_1 = F_2 = G\frac{m_1 \times m_2}{r^2}$$