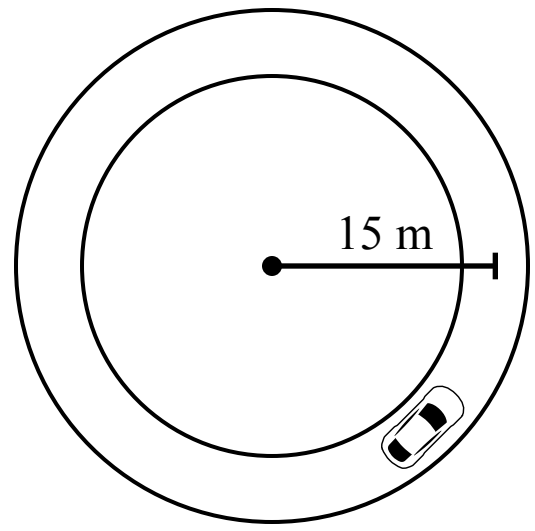
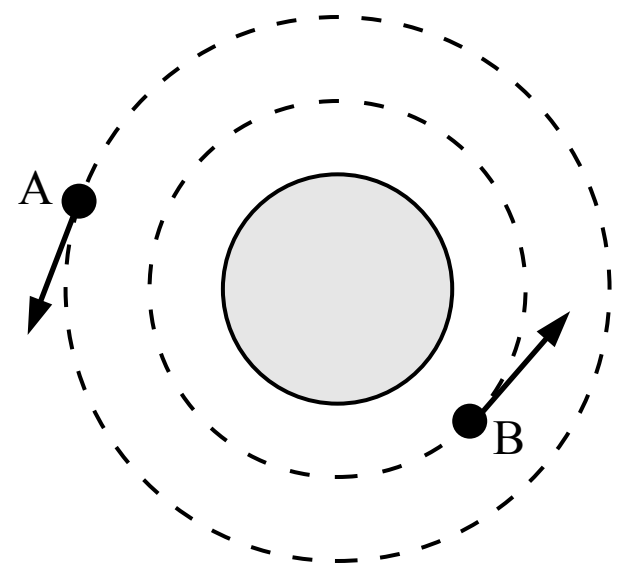
CIRCULAR MOTION



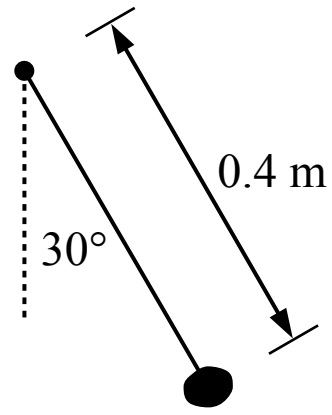
1. A car is driving at a speed of 22 m/s around a circular track as shown in the figure above. During a period of 3 seconds the car slows down at a rate of 2 m/s². What distance does the car travel during that time?

   (A) 57 m
   (B) 66 m
   (C) 75 m
   (D) 121 m

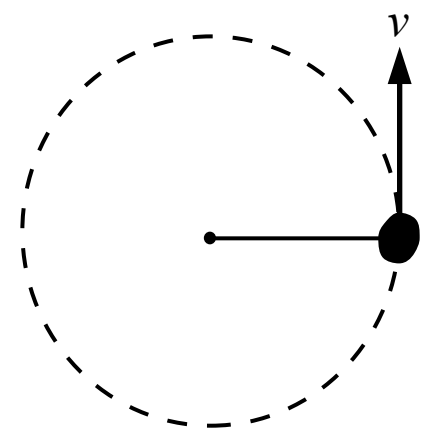


2. Two satellites are in orbit around the earth as shown in the figure above. The satellites are at different heights above the surface of the earth and they each travel at a constant speed. If satellite A orbits the earth with a greater period, how does the orbital frequency of satellite A compare with the orbital frequency of satellite B?

   (A) $f_A = f_B$
   (B) $f_A > f_B$
   (C) $f_A < f_B$
   (D) Cannot be determined



Side view



Top view

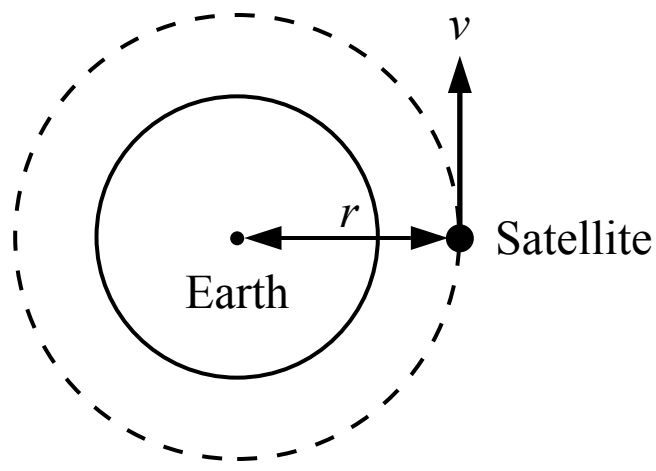
3. A rock is attached to a 0.4 m long string and is swung through the air so that the path of the rock follows a horizontal circle as shown in the top view figure above. The string makes a 30° angle with the vertical as shown in the side view figure. The rock completes one revolution per second. The speed of the rock is most nearly

(A) 0.6 m/s

(B) 1.3 m/s

(C) 2.2 m/s

(D) 2.5 m/s



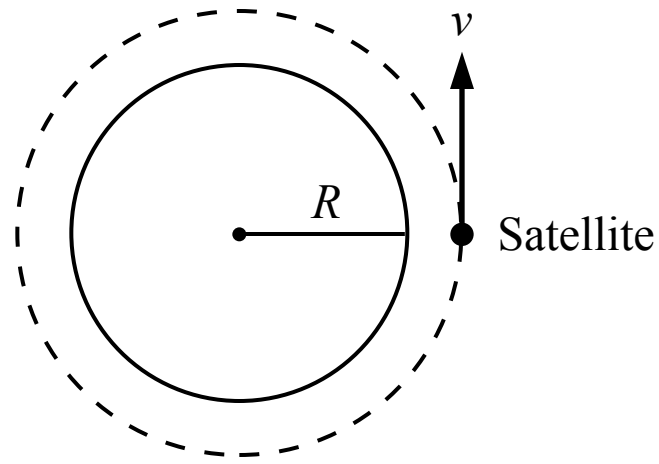
4. A satellite follows a circular orbit around the earth at a constant speed as shown in the figure above. How long does it take to complete one orbit?

(A) $2\pi r$

(B) $\dfrac{r}{v}$

(C) $2\pi r v$

(D) $\dfrac{2\pi r}{v}$



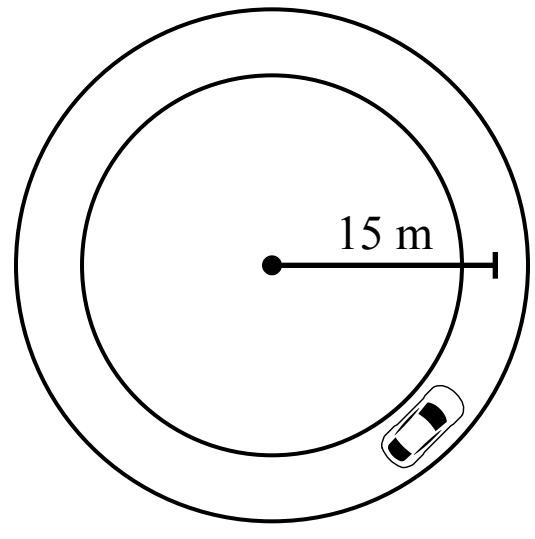
5. A satellite is in a circular orbit around the Earth at height of 2,000 km above the surface of the earth. The radius of the earth is 6,371 km. If the satellite completes one orbit every 2 hours, the speed of the satellite is most nearly

(A) 1.7 km/s

(B) 5.6 km/s

(C) 6.4 km/s

(D) 7.3 km/s



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A **Correct**

The distance the car travels during the 3 second period can be found using the kinematic equation below, which is the same as the equation for a car driving on a straight road. The radius of the track is not relevant. The value for acceleration is negative because the car is slowing down.

$$\Delta s = v_0 t + \frac{1}{2} a t^2 = (22 \text{ m/s})(3 \text{ s}) + \frac{1}{2}(-2 \text{ m/s}^2)(3 \text{ s})^2 = 57 \text{ m}$$

B Incorrect

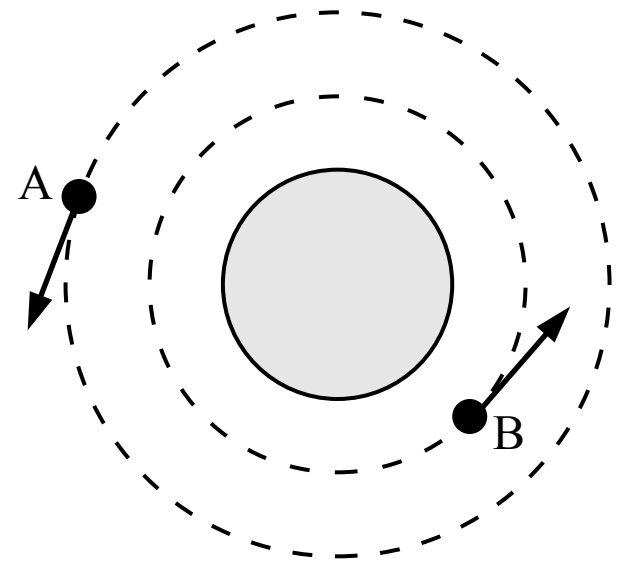
This answer is the distance the car would travel at the initial speed without the acceleration.

C Incorrect

This answer incorrectly uses a positive value instead of a negative value for the acceleration.

D Incorrect

This answer uses an incorrect kinematic equation and assumes the car comes to a stop after 3 seconds.



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(A) $f_A = f_B$
(B) $f_A > f_B$
(C) $f_A < f_B$
(D) Cannot be determined

A Incorrect

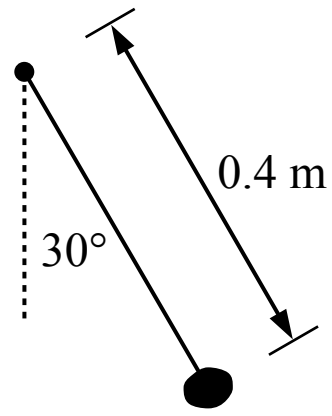
B Incorrect

C Correct

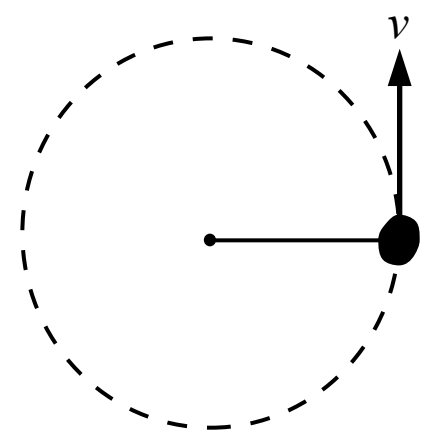
Frequency is the number of cycles per second (in this case orbits per second) and is the inverse of the period as shown below. If satellite A has a greater period then it has a smaller or shorter frequency.

$$f = \frac{1}{T}$$

D Incorrect



Side view



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(A) 0.6 m/s

(B) 1.3 m/s

(C) 2.2 m/s

(D) 2.5 m/s

A Incorrect

This answer incorrectly uses 0.2 m as the diameter of the circular path instead of the radius.

B Correct

The radius of the circular path is the horizontal component of the string length. The rock travels a distance of 1 circumference per second.

$r = (0.4\text{ m})\sin(30°) = 0.2\text{ m}$

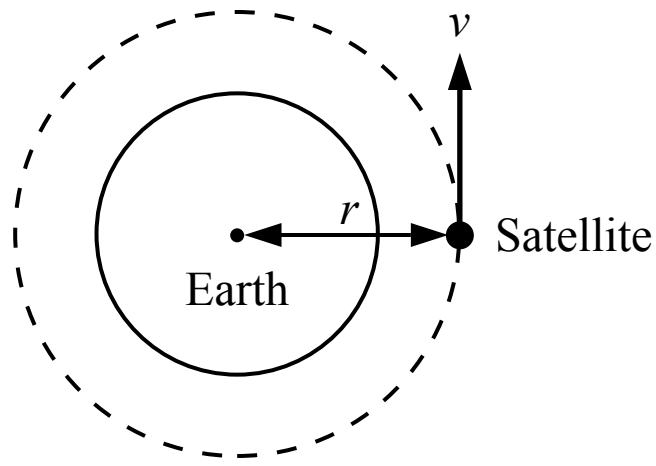
$$v = \frac{d}{t} = \frac{2\pi r}{T} = \frac{2\pi(0.2\text{ m})}{1\text{ s}} = 1.3\text{ m/s}$$

C Incorrect

This answer incorrectly uses $\cos(30°)$ instead of $\sin(30°)$ to find the radius.

D Incorrect

This answer incorrectly uses 0.4 m as the radius of the circular path.



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(A) $2\pi r$

(B) $\frac{r}{v}$

(C) $2\pi r v$

(D) $\frac{2\pi r}{v}$

A Incorrect

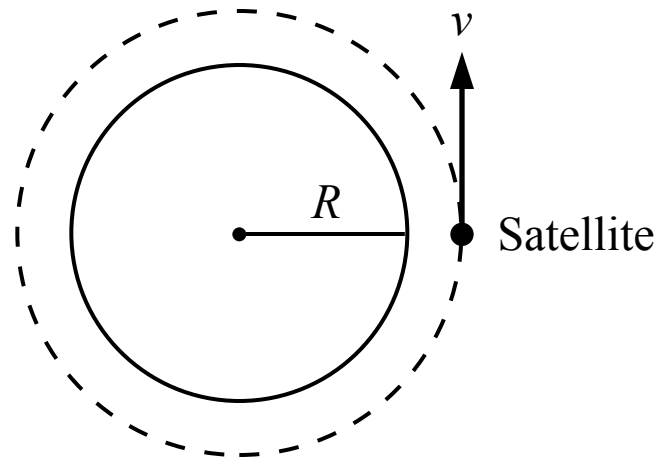
B Incorrect

C Incorrect

D Correct

The speed of the satellite is equal to the distance the satellite travels (the linear distance or the arc length) divided by a period of time. The question is asking for the amount of time it takes the satellite to travel a distance of one circumference of its circular path.

$$v = \frac{d}{\Delta t} = \frac{\Delta s}{\Delta t} \qquad \Delta t = \frac{\Delta s}{v} = \frac{2\pi r}{v}$$



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(D) 7.3 km/s

A Incorrect

This answer incorrectly uses 2,000 km for the radius of the orbit.

B Incorrect

This answer incorrectly uses 6,371 km for the radius of the orbit.

C Incorrect

This answer incorrectly uses 7,371 km for the radius of the orbit.

D Correct

The radius of the orbit is the radius of the earth plus the height of the satellite above the surface of the earth.

$$v = \frac{2\pi r}{t} = \frac{2\pi(6{,}371\text{ km} + 2{,}000\text{ km})}{2\text{ h}} = 26{,}299\text{ km/h} \qquad \frac{26{,}299\text{ km}}{\text{h}} \times \frac{1\text{ h}}{60\text{ min}} \times \frac{1\text{ min}}{60\text{ s}} = 7.3\text{ km/s}$$