

AP Physics C – Circular Motion Complete Answers

1. a. If acceleration is zero then an object's velocity must remain constant, including the direction of travel. Therefore a car that does not accelerate would move in a straight line, not a curve.
b. An object undergoing a constant acceleration moves either in a straight line or a parabolic path. In principle a car could move along a parabolic stretch of roadway with a constant acceleration. However, if a car is launched off a ramp and goes airborne then it is definitely following a parabolic path with a constant acceleration of g (because it is then a projectile!)
c. A circular curve involves acceleration toward the center of the circle at all times and therefore the direction of the acceleration vector must continuously change and point in different directions relative to earth. This means that acceleration (which includes direction) is not a constant value.
2. a. 120 m/s^2 toward center
b. 110 N toward center
c. 6.6 m/s
3. a. 7.9 m/s
b. 210 m/s^2 toward center
c. 1.0 N toward center
d. 0.048
4. $f = \frac{1}{2\pi} \sqrt{\frac{\mu_s g}{r}}$
5. a. 1.05 m/s^2
b. $a = \frac{\pi}{180} \frac{v\theta}{t}$ (θ in degrees)
 $a = \frac{v\theta}{t}$ (θ in radians)
6. a. The centripetal force is the horizontal component of the tension in the string and this equals mass times acceleration. The vertical component of the tension in the string balances with the weight of the mass and therefore equals mg . By similar triangles the ratio of these components is equal to the ratio of radius to height: $\frac{T_x}{T_y} = \frac{ma}{mg} = \frac{r}{h}$ Therefore: $a = g \frac{r}{h}$
b. $T = 2\pi \sqrt{\frac{h}{g}}$
7. a. 18 kN
b. 20 m/s
c. 3.8 s
8. a. 13.1 m/s
b. 35 m/s
9. a. 350 m
b. 640 m
10. a. 6.2 m
b. 16 m/s

11. a. The ball has inertia. When the ball is released it is already moving with a certain velocity. With no significant force to cause any acceleration it continues on a tangent path with a certain velocity due to its inertia (not due to a force). From the perspective of the boy it *appears* to accelerate away from the center (when in *reality* it is the effect of the boy accelerating inwardly away from the ball).

b. 1.9 m/s^2 away from center
c. 0.46 N

12. a. 0.034 m/s^2 toward center or down
b. 2.7 N
c. 1.4 h

13. a. $T = \pi \sqrt{\frac{2d}{g}}$

b. 450 m

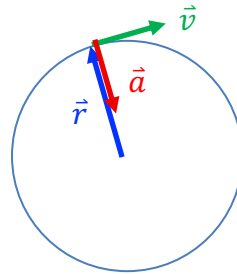
14. a. 2.0 m , 106° from origin

b. 6.0 m/s , 16°

c. 18 m/s^2 , 286°

d. 2.1 s

e. diagram of path and vectors:



15. a.
$$x = -6t + 0.33 \cos\left(18.18t - \frac{\pi}{2}\right)$$
 OR
$$x = -6t + 0.33 \sin(18.18t)$$

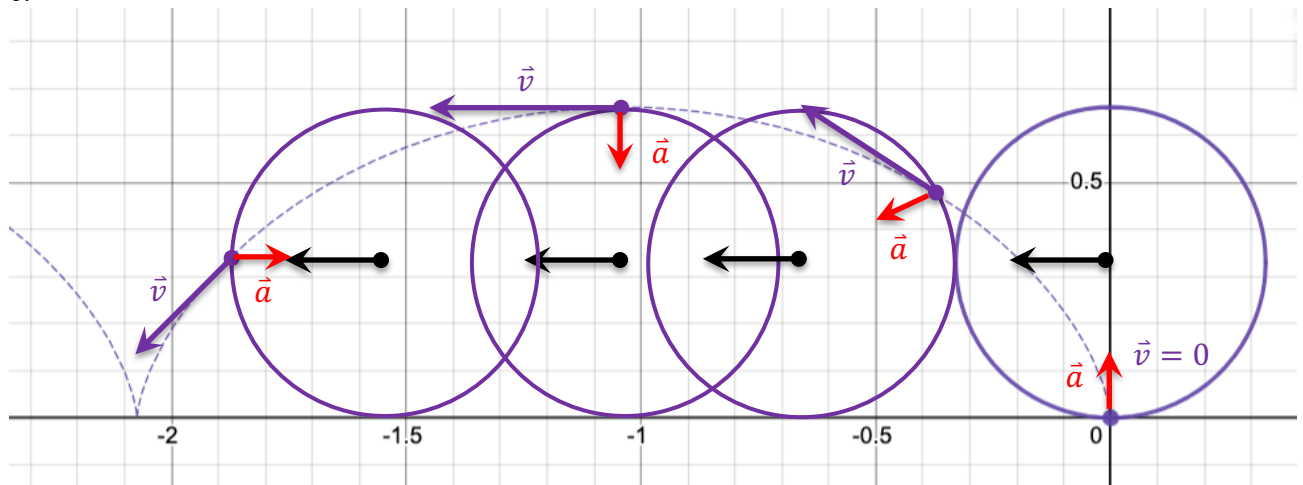
$$y = 0.33 + 0.33 \sin\left(18.18t - \frac{\pi}{2}\right)$$

$$y = 0.33 - 0.33 \cos(18.18t)$$

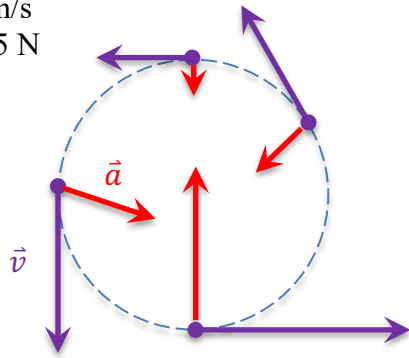
b. 12 m/s (to the left)

at $t = 0.173 \text{ s}$, 0.519 s , 0.864 s , etc

c.



16. a. 2.97 m/s
b. 6.64 m/s
c. 0; 7.35 N
d.



17. a. Friction is initially tangent, then becoming more and more radial
b. Friction points in the direction of acceleration. The initial radial component of acceleration is zero, so friction is initially tangent. As the speed of the object increases, the radial component of acceleration increases causing friction to tilt away from tangent and point more toward the center as the surface rotates. Eventually the acceleration vector is perpendicular to the original tangent direction. The angle at which this occurs satisfies the equation: $\tan \theta = \frac{1}{2\theta}$, which has solution $\theta = 0.65327 = 37.4^\circ$.

c. $\theta = \frac{1}{2} \sqrt{\frac{\mu_s^2 g^2}{a^2} - 1}$

18. a. 9.42 s
b. 4.46 m/s², 328.8°