EXERCISES 8.B

1. Can an object accelerate if its speed is constant? Can an object accelerate if its velocity is constant?
2. If you know the position vectors of a particle at two points along its path and also know the time it took to move from one point to the other, can you determine the particle's instantaneous velocity? Its average velocity? Explain.
3. A baseball is thrown with an initial velocity of $(10\vec{\imath}+15\vec{\jmath})$ m/s. When it reaches the top of its trajectory, what are:
   (a) its velocity and
   (b) its acceleration? Neglect the effect of air resistance.
4. A rock is dropped at the same instant that a ball, at the same initial elevation, is thrown horizontally. Which will have the greater speed when it reaches ground level?
5. Determine which of the following moving objects obey the equations of projectile motion developed in this unit.
a) A ball is thrown in an arbitrary direction.
b) A jet airplane crosses the sky with its engines thrusting the plane forward.
c) A rocket leaves the launch pad.
d) A rocket moving through the sky after its engines have failed.
e) A stone is thrown under water.
6. How can you throw a projectile so that it has zero speed at the top of its trajectory? So that it has nonzero speed at the top of its trajectory?
7. Two projectiles are thrown with the same magnitude of initial velocity, one at an angle θ with respect to the level ground and the other at angle $90°-\theta$. Both projectiles will strike the ground at the same distance from the projection point. Will both projectiles be in the air for the same time interval?
8. A projectile is launched at some angle to the horizontal with some initial speed *vi*, and air resistance is negligible. Is the projectile a freely falling body? What is its acceleration in the vertical direction? What is its acceleration in the horizontal direction?
9. State which of the following quantities, if any, remain constant as a projectile moves through its parabolic trajectory:
a) Speed, b) acceleration, c) horizontal component of velocity, d) vertical component of velocity.
10. A projectile is fired at an angle of 30° from the horizontal with some initial speed. Firing the projectile at what other angle results in the same horizontal range if the initial speed is the same in both cases? Neglect air resistance.
11. The maximum range of a projectile occurs when it is launched at an angle of 45.0° with the horizontal, if air resistance is neglected. If air resistance is not neglected, will the optimum angle be greater or less than 45.0°? Explain.

Section 1. The Position, Velocity, and Acceleration Vectors

1. A motorist drives south at 20.0 m/s for 3.00 min, then turns west and travels at 25.0 m/s for 2.00 min, and finally travels northwest at 30.0 m/s for 1.00 min. For this 6.00-min trip, find:
a) The total vector displacement,
b) The average speed, and
c) The average velocity. Let the positive *x* axis point east.
2. When the Sun is directly overhead, a hawk dives toward the ground with a constant velocity of 5.00 m/s at 60.0° below the horizontal. Calculate the speed of her shadow on the level ground.
3. The coordinates of an object moving in the *xy* plane vary with time according to the equations $x = -(5\text{ m})\sin(\omega t)$ and $y = (4\text{m}) - (5.00\text{ m})\cos(\omega t)$, where ω is a constant and t is in seconds.
(a) Determine the components of velocity and components of acceleration at $t = 0$.
(b) Write expressions for the position vector, the velocity vector, and the acceleration vector at any time $t > 0$
(c) Describe the path of the object in an *xy* plot.

Section 2. Two-Dimensional Motion with Constant Acceleration

1. At $t = 0$, a particle moving in the *xy* plane with constant acceleration has a velocity of $v_i = (3\vec{\imath} - 2\vec{\jmath})$ m/s and is at the origin. At $t = 3$s, the particle's velocity is $v = (9\vec{\imath} +\& 7\vec{\jmath})$ m/s. Find
a) the acceleration of the particle and
b) its coordinates at any time *t*.
2. The vector position of a particle varies in time according to the expression $r=(3\vec{\imath} - 6t^2\vec{\jmath})$ m.
(a) Find expressions for the velocity and acceleration as functions of time.
(b) Determine the particle's position and velocity at $t = 1$ s.
3. A fish swimming in a horizontal plane has velocity $v_i = (4\vec{\imath}+1\vec{\jmath})$ m/s at a point in the ocean where the position relative to a certain rock is $r_i = (10\vec{\imath} - 4\vec{\jmath})$ m. After the fish swims with constant acceleration for 20.0 s, its velocity is $v=(20\vec{\imath} - 5\vec{\jmath})$ m/s.
(a) What are the components of the acceleration?

(b) What is the direction of the acceleration with respect to unit vector $\vec{\imath}$?
(c) If the fish maintains constant acceleration, where is it at t = 25s, and in what direction is it moving?
4. A particle initially located at the origin has an acceleration of a= $3\vec{\jmath}$ m/s^2 and an initial velocity of $v_{i=}$ $500\vec{\imath}$ m/s. Find :
(a) the vector position and velocity at any time t and
(b) the coordinates and speed of the particle at t= 2s.
5. It is not possible to see very small objects, such as viruses, using an ordinary light microscope. An electron microscope can view such objects using an electron beam instead of a light beam. Electron microscopy has proved invaluable for investigations of viruses, cell membranes and subcellular structures, bacterial surfaces, visual receptors, chloroplasts, and the contractile properties of muscles. The "lenses" of an electron microscope consist of electric and magnetic fields that control the electron beam. As an example of the manipulation of an electron beam, consider an electron traveling away from the origin along the x axis in the xy plane with initial velocity v_i= $v_i\vec{\imath}$. As it passes through the region x =0 to x = d, the electron experiences acceleration a= $a_x\vec{\imath}+a_y\vec{\jmath}$, where a_x and a_y are constants. For the case v_i = 1.80 × 10^7 m/s, a_x = 8 ×10^{14} m/s^2
and a_y =1.6 × 10^{15} m/s^2, determine at x =d =0.0100 m
(a) the position of the electron,
(b) the velocity of the electron,
(c) the speed of the electron, and
(d) the direction of travel of the electron (i.e., the angle between its velocity and the x axis).

Section 3. Projectile Motion

Note: **Ignore air resistance in all problems and take g = 9.80 m/s^2 at the Earth's surface.**

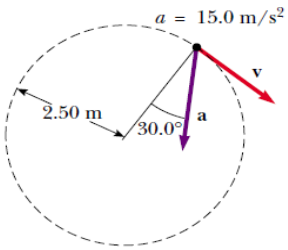
1. To start an avalanche on a mountain slope, an artillery shell is fired with an initial velocity of 300 m/s at 55.0° above the horizontal. It explodes on the mountainside 42.0 s after firing. What are the x and y coordinates of the shell where it explodes, relative to its firing point?
2. In a local bar, a customer slides an empty beer mug down the counter for a refill. The bartender is momentarily distracted and does not see the mug, which slides off the counter and strikes the floor 1.40 m from the base of the counter. If the height of the counter is 0.860 m,
a) with what velocity did the mug leave the counter, and
b) what was the direction of the mug's velocity just before it hit the floor?
3. In a local bar, a customer slides an empty beer mug down the counter for a refill. The bartender is momentarily distracted and does not see the mug, which slides off the counter and strikes the floor at distance d from the base of the counter. The height of the counter is h.
(a) With what velocity did the mug leave the counter, and
(b) what was the direction of the mug's velocity just before it hit the floor?
4. One strategy in a snowball fight is to throw a snowball at a high angle over level ground. While your opponent is watching the first one, a second snowball is thrown at a low angle timed to arrive before or at the same time as the first one. Assume both snowballs are thrown with a speed of 25.0 m/s. The first one is thrown at an angle of 70.0° with respect to the horizontal.
(a) At what angle should the second snowball be thrown to arrive at the same point as the first?
(b) How many seconds later should the second snowball be thrown after the first to arrive at the same time?
5. An astronaut on a strange planet finds that she can jump a maximum horizontal distance of 15.0 m if her initial speed is 3.00 m/s. What is the free-fall acceleration on the planet?
6. A projectile is fired in such a way that its horizontal range is equal to three times its maximum height. What is the angle of projection?
7. A rock is thrown upward from the level ground in such a way that the maximum height of its flight is equal to its horizontal range d.
(a) At what angle θ is the rock thrown?
b) What If? Would your answer to part (a) be different on a different planet?
(c) What is the range d_{max} the rock can attain if it is launched at the same speed but at the optimal angle for maximum range?
8. A ball is tossed from an upper-story window of a building.The ball is given an initial velocity of 8.00 m/s at an angle of 20.0° below the horizontal. It strikes the ground 3.00 s later.
(a) How far horizontally from the base of the building does the ball strike the ground?
(b) Find the height from which the ball was thrown.
(c) How long does it take the ball to reach a point 10.0 m below the level of launching?

9.A place-kicker must kick a football from a point 36.0 m (about 40 yards) from the goal, and half the crowd hopes the ball will clear the crossbar, which is 3.05 m high. When kicked, the ball leaves the ground with a speed of 20.0 m/s at an angle of 53.0° to the horizontal.
a) By how much does the ball clear or fall short of clearing the crossbar?
b) Does the ball approach the crossbar while still rising or while falling?
10. A playground is on the flat roof of a city school, 6.00 m above the street below. The vertical wall of the building is 7.00 m high, to form a meter-high railing around the playground. A ball has fallen to the street below, and a passerby returns it by launching it at an angle of 53.0° above the horizontal at a point 24.0 meters from the base of the building wall. The ball takes 2.20 s to reach a point vertically above the wall.
(a) Find the speed at which the ball was launched.
(b) Find the vertical distance by which the ball clears the wall.
(c) Find the distance from the wall to the point on the roof where the ball lands.
11. A dive bomber has a velocity of 280 m/s at an angle ' below the horizontal. When the altitude of the aircraft is 2.15 km, it releases a bomb, which subsequently hits a target on the ground. The magnitude of the displacement from the point of release of the bomb to the target is 3.25 km. Find the angle θ.
12. A soccer player kicks a rock horizontally off a 40m high cliff into a pool of water. If the player hears the sound of the splash 3s later, what was the initial speed given to the rock? Assume the speed of sound in air to be 343 m/s.

Section 5. Tangential and Radial Acceleration

1.A train slows down as it rounds a sharp horizontal turn, slowing from 90.0 km/h to 50.0 km/h in the 15.0 s that it takes to round the bend. The radius of the curve is 150 m. Compute the acceleration at the moment the train speed reaches 50.0 km/h. Assume it continues to slow down at this time at the same rate.
2. An automobile whose speed is increasing at a rate of 0.600 m/s^2 travels along a circular road of radius 20.0 m. When the instantaneous speed of the automobile is 4.00 m/s, find
(a) the tangential acceleration component,
(b) the centripetal acceleration component, and
(c) the magnitude and direction of the total acceleration.

3.Figure represents the total acceleration of a particle moving clockwise in a circle of radius 2.50 m at a certain instant of time. At this instant,
find :(a) the radial acceleration,
(b) the speed of the particle, and
(c) its tangential acceleration.



4. A ball swings in a vertical circle at the end of a rope 1.50 m long. When the ball is 36.9° past the lowest point on its way up, its total acceleration is $(-22.5\vec{i} + 20.2\vec{j})$ m/s^2. At that instant,
(a) sketch a vector diagram showing the components of its acceleration,
(b) determine the magnitude of its radial acceleration, and
(c) determine the speed and velocity of the ball.
5. A race car starts from rest on a circular track. The car increases its speed at a constant rate *at* as it goes once around the track. Find the angle that the total acceleration of the car makes with the radius connecting the center of the track and the car at the moment the car completes the circle.