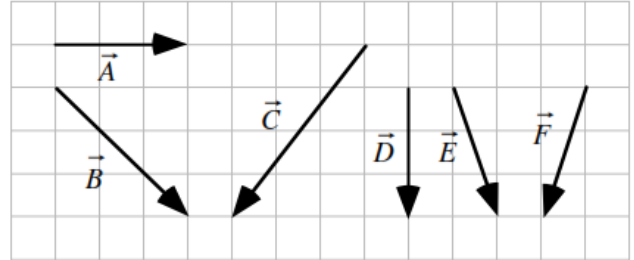AP Physics 1
Unit 1 2-D Motion Practice Exercises

Directions: Show the steps required to arrive at the answer (if applicable). For all problems, g = 9.80 m/s^2.
Work out the problems on separate page.

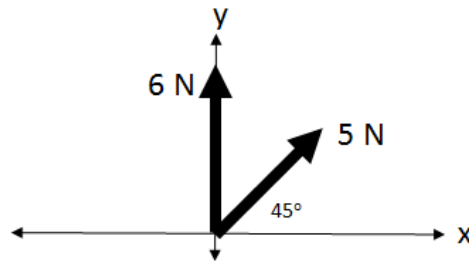2.1 – Vectors
1. Consider the vectors shown below.
a) Rank the x-components of each vector.
b) Rank the y-components of each vector.

2. A 9.0 N force and a 12 N force act concurrently on an object.
a) What is the smallest possible resultant of the two forces?
b) What is the largest possible resultant of the two forces?

3. Find the resultant force.

4. Luffy pilots the Thousand Sunny across the ocean. He
pilots the boat with a velocity of 50 m/s 45º south of west
as shown. There is a strong ocean current pushing on his
boat that is direction 30º north of west as shown. What is
the resultant velocity of Sebastian's boat?
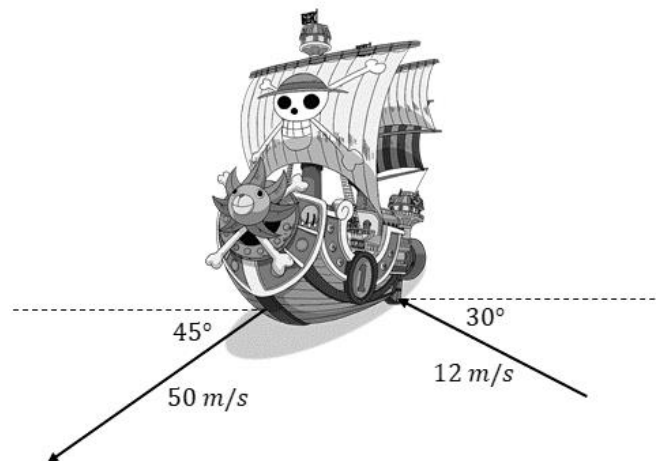
5. A 57 N force acts 40° south of east and a 70 N acts 80° north of west. Find the magnitude and direction of the
resultant force.

6. Frodo and Sam paddle a boat directly north across a 10 m wide (west to east) river at a rate of 3 m/s. The
river has a current acting directly east at a rate of 1 m/s. How far east do they drift down the river as they paddle
across?

*7. A force of 100 N acts upward. Resolve this force into 2 components; one that acts 30° north of west and one
that acts 60° north of east.

2.2 – Projectile Motion

1. A ball is thrown straight up into the air from the top of a building and hits the ground below. Sketch the graphs of displacement, velocity, and acceleration of the object while in motion.

2. A ball is thrown straight up into the air and returns to the level from which it was thrown. State how the given quantity changes while the ball is in the air.
     a) height of the ball   b) velocity of the ball   c) speed of the ball   d) acceleration of the ball

3. A baseball leaves a bat with an initial velocity of 65 m/s. The velocity vector initially makes an angle of 35° with the horizontal.
     a) What is the ball's initial horizontal velocity component?
     b) What is the ball's initial vertical velocity component?

4. A bullet is fired horizontally and a second bullet is released from rest at the same height as the gun. Ignoring air resistance, which bullet strikes the ground first? Justify your answer.

5. The rifles in the figures are being fired horizontally (straight outward, off platforms). The bullets fired form the rifles are all identical, but the rifles propel the bullets at different speeds. The speed of each bullet and the height of each platform are given. All of the bullets miss the targets and hit the ground.
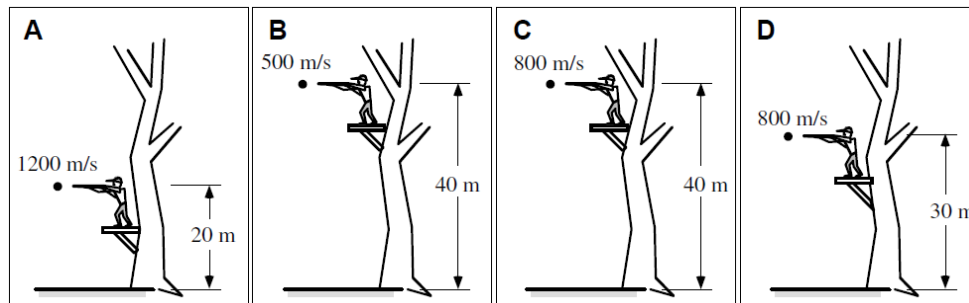
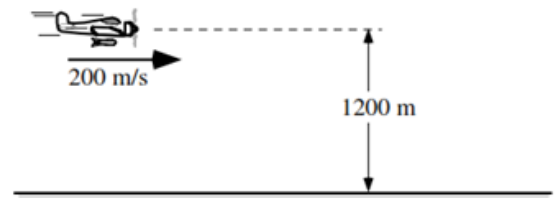Rank the time it takes the bullets to hit the ground. Explain your reasoning.

6. Consider the following projectiles:
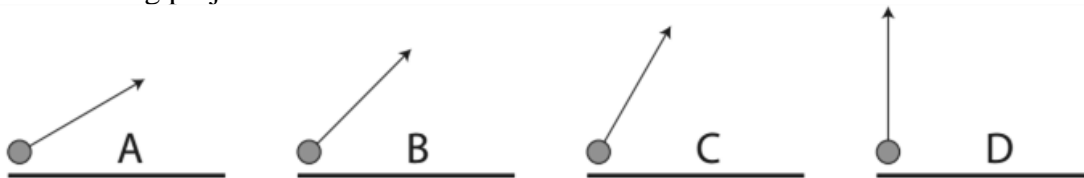
   a) Rank the projectiles in terms of maximum height reached.
   b) Rank the projectiles in terms of horizontal distance traveled.
   c) Rank the projectiles in terms of acceleration while in the air.

7. A projectile is fired with a speed of v. The projectile's initial velocity makes an angle of $\emptyset$ with the horizontal.
     a) How high does the projectile rise?
     b) How far will the projectile land from the place it was fired?

8. A stone is thrown with a speed of 20 m/s at an angle of 30° above the horizontal. The stone is thrown from the roof of a 35 m tall building.
     a) How long does the stone remain in the air?
   b) How far from the building does the stone land?

9. A shell is fired at 400 m/s at an angle of 25° above the horizontal. The plane of the shell's path is perpendicular to a vertical cliff 8000m from the place it is fired. (The shell is fired directly at the cliff.)
  a) How long after the shell is fired will it strike the cliff?
  b) How high above the base of the cliff will the shell strike?
  c) What is the shell's speed when it strikes the cliff?
  d) What angle does the shell's velocity make with the horizontal just before the shell strikes the cliff?

10. Water flows horizontally from a hose that is 3.0 m above the ground. The water lands 7.2 m to the right of the hose.
  a) How long does the water take to reach the ground?
  b) With what speed does the water leave the hose?
  c) What is the vertical component of the water's velocity the instant before it hits the ground?
  d) What is the horizontal component of the water's velocity the instant before it hits the ground?
  e) What is the speed of the water the instant before it hits the ground?

11. A stone is thrown horizontally at a speed of 20.0 m/s from the roof of a building 35.0 m above the ground.
  a) How long is the stone in the air?
  b) How far does the stone land from the foot of the building?
  c) With what speed does the stone strike the ground?
  d) What angle does the stone's velocity make with the horizontal just before impact?

12. An airplane flies 1200 m above ground at a speed of 200 m/s. It drops a bomb that hits the ground after traveling horizontally 3130 m. For each of the following, determine what will happen to the horizontal distance the bomb travels if the conditions above are changed as follows:
  a) The plane's speed is tripled.
  b) The plane flies straight up at the release point.
  c) The plane is flying in a level altitude at 1100 m.
  d) The mass of the bomb is increases.
  e) The ball is thrown downward from the plane at 15 m/s.

200 m/s

1200 m

13. All three cannons launch an identical mass with the same launch speed. The two angled projectiles are launched at the same angle above the horizontal. The two projectiles launched off a cliff are launched from the same height above the ground.
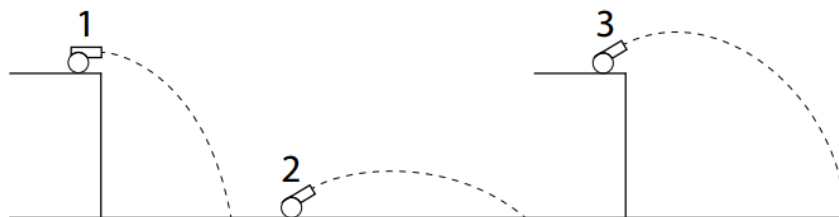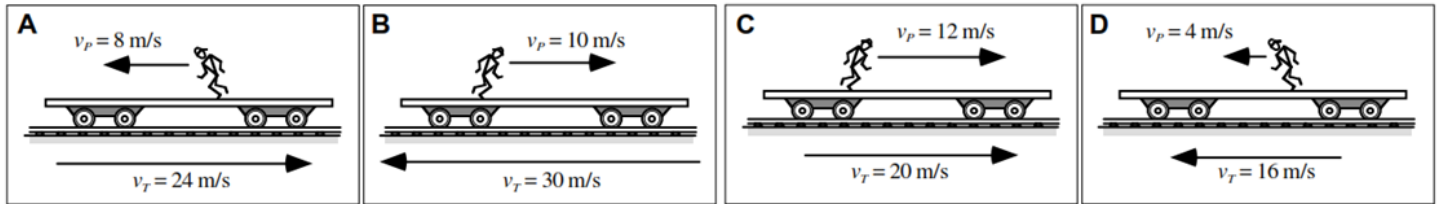

  a) Rank the resultant velocities at max height of the projectile in each case. Justify your answer.
  b) Rank the speed the projectile hits the ground in each case. Justify your answer.

14. A baseball is hit with a velocity of 40 m/s at an angle of 30° above the horizontal. Giancarlo Stanton runs at 4.0 m/s at the crack of the bat and manages to catch the ball as he runs straight toward home plate. He catches the ball just as it is about to strike the ground. How far was Giancarlo from the batter when the ball was hit?

2.3 – Relative Velocity

1. In each case shown, someone is running on a flatbed train car as the train moves. In cases C and D, the person is running toward the front of the train, while in cases A and B the person is running toward the rear. The speeds of the train and of each person relative to the train are given. An observer is standing beside the track watching each train go by.

| A	B	C	D
$v_P = 8$ m/s	$v_P = 10$ m/s	$v_P = 12$ m/s	$v_P = 4$ m/s
$v_T = 24$ m/s	$v_T = 30$ m/s	$v_T = 20$ m/s	$v_T = 16$ m/s

Rank the speed of the runners relative to the observer standing beside the tracks. Explain your reasoning.
the time it takes until the trains crash into each other.

2. Upon seeing that the in-flight movie is "Star Wars Episode VIII: The Last Jedi", a passenger jumps out of the airplane wearing a parachute. At some point, the passenger is traveling straight down through the air at a constant velocity of 10 m/s. A constant wind blows east as shown. From the point shown, the passenger falls a distance of 1500 m at constant velocity. During this time, the passenger drifts a distance of 950 m to the east. Calculate the speed of the wind.

Wind →

10 m/s
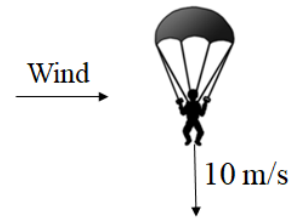
3. Boris drive a car at 30 m/s due east as shown.

30 m/s
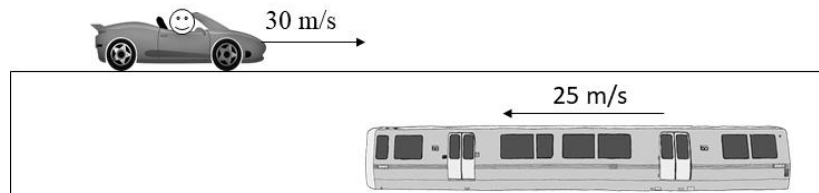
25 m/s

a) Directly below him, a subway travels due west at 25 m/s. Vladimir, a passenger on the subway, walks towards the back of the subway at 2 m/s. Calculate how fast Boris is moving towards Vladimir.
b) While driving, Boris throws a stapler in the air.
   i. Draw the path of the stapler as seen by Boris.
   ii. Draw the path of the stapler as seen by Angela, who is an observer at rest on the side of the rod.
   iii. 1 second after being thrown up, the stapler is traveling directly upwards at 2 m/s. Calculate the speed of the stapler as viewed by Angela, the rest observer.