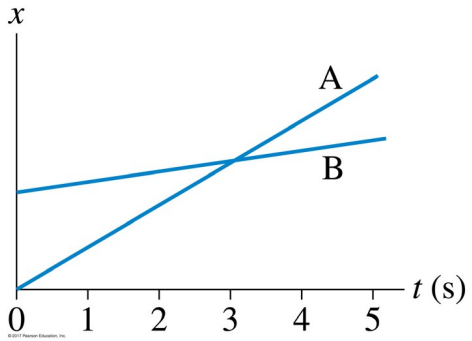
Addis Ababa University
College of Natural and Computational Sciences
Department of Physics
Phys 1011 Worksheet I

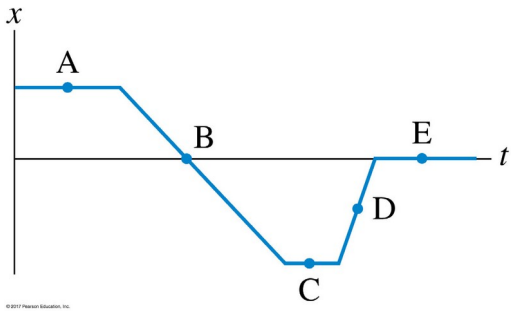
Conceptual Questions

1. Astronomers sometimes measure distances in astronomical units, where, $1\,AU = 1.496 \times 10^{11} m$, the mean distance from Earth to Sun. Why is this useful for distances within our solar system?
2. Describe a situation in which you might find it practical to use a non-SI unit.
3. Explain the difference between dimensions and units.
4. Can you add or subtract quantities with different units? Can you multiply or divide quantities with different units?
5. If $\vec{C}$ is the vector sum of $\vec{A}$ and $\vec{B}$, $\vec{C} = \vec{A} + \vec{B}$, what must be true about the directions and magnitudes of $\vec{A}$ and $\vec{B}$ if $C = A + B$? What must be true about the directions and magnitudes of $\vec{A}$ and $\vec{B}$ if $C = 0$?
6. If $\vec{A} = 0$ for a vector in the xy-plane, does it follow that $A_x = -A_y$? What can you say about A_x and A_y?
7. Can you find a vector quantity that has a magnitude of zero but components that are different from zero? Explain. Can the magnitude of a vector be less than the magnitude of any of its components? Explain.
8. The figure below shows a position-versus-time graph for the motion of objects A and B as they move along the same axis. **(a)** At the instant t = 1 s, is the speed of A greater than, less than, or equal to the speed of B? *Explain*. **(b)** Do objects A and B ever have the same speed? If so, at what time or times? *Explain*.



9. You toss a small ball vertically up in the air. How are the velocity and acceleration vectors of the ball oriented with respect to one another during the ball's flight up and down?
10. If the acceleration of an object is zero and its velocity is nonzero, what can you say about the motion of the object?

11. The figure below shows the position-versus-time graph for a moving object. At which letter point or points: **(a)** Is the object moving the slowest? **(b)** Is the object moving the fastest? **(c)** Is the object at rest? **(d)** Is the object moving to the left?



12. Under what conditions is average velocity equal to instantaneous velocity?
13. Under what conditions does the magnitude of the average velocity equal the average speed?
14. Can an object's acceleration be in the opposite direction to its motion? Explain.
15. Give examples of motion in which the directions of the velocity and acceleration vectors are (a) opposite, (b) the same, and (c) mutually perpendicular.
16. "In general, the normal force is not equal to the weight." Give an example where the two forces are equal in magnitude and at least two examples where they are not.
17. To push a box up an inclined plane, is the force required smaller if you push horizontally or if you push parallel to the incline? Why?
18. Can the magnitude of the displacement of a particle be less than the distance traveled by the particle along its path? Can its magnitude be more than the distance traveled? Explain.
19. For an observer in an inertial reference frame, identify which (if any) of the following statements are true and which (if any) are false.
    (a) If there are no forces acting on an object, it will not accelerate.
    (b) If an object is not accelerating, there must be no forces acting on it.
    (c) The motion of an object is always in the direction of the resultant force.
    (d) The mass of an object depends on its location.

Problems

1. How many significant figures are in each of the following numbers?
   (a) 4.01 (b) 4.010 (c) 4 (d) 2.00001 (e) 0.00001 (f) 1.10042 (g) 2310000
2. Two different forces, acting on the same object, are measured. One force is 2.0031 N and the other force, in the same direction, is 3.12 N. These are the only forces acting on the object. Find the total force on the object to the correct number of significant figures.
3. Given the equation $w = xyz$, and $x = 1.1 \times 10^{3}$, $y = 2.48 \times 10^{-2}$, and $z = 6.000$, what is w, in scientific notation and with the correct number of significant figures?

4. The length and width of a rectangular room are measured to be 3.955 ± 0.005 m and 3.050 ± 0.005 m. Calculate (a) the relative and percentage errors in measuring the length and width; (b) the area of the room and its uncertainty in square meters.
5. A car engine moves a piston with a circular cross section of 7.500 ± 0.002 cm diameter a distance of 3.250 ± 0.001 cm to compress the gas in the cylinder. (a) By what amount is the gas decreased in volume in cubic centimeters? (b) Find the uncertainty in this volume.
6. Apply the appropriate rule for significant figures to calculate the following: (a) 1.58 x 0.03, (b) 1.4 + 2.53, (c) 2.34 x 10^2 + 4.93 (Answer (a) 0.05, (b) 3.9, (c) 2.39 x 102)
7. In the following equations, the distance x is in meters, the time t is in seconds, and the velocity v is in meters per second. What are the SI units of the constants C_1 and C_2 ?

   (a) $x = C_1 + C_2 t$, (b) $x = \frac{1}{2} C_1 t^2$, (c) $v^2 = 2 C_1 x$, (d) $x = C_1 \cos\left(C_2 t\right)$,

   (e) $v^2 = 2 C_1 v - \left(C_2 x\right)^2$
8. Calculate the following, round off to the correct number of significant figures, and express your result in scientific notation: (a) (200.9)x(569.3),
   (b) (0.000000513)x(62.3 x 10^7), (c) 28,401 + (5.78 X 10^4), (d) 63.25 / (4.17 x 10^{-3}).
9. A cell membrane has a thickness of about 7 nm. How many cell membranes would it take to make a stack 1 in high?
10. The volume of an irregularly shaped solid can be determined from the volume of water it displaces. A graduated cylinder contains 19.9 mL of water. When a small piece of galena, an ore of lead, is added, it sinks and the volume increases to 24.5 mL. What is the volume of the piece of galena in cm^3, m^3, and in L?
11. Calculate the result of each of the following problems to the correct number of significant digits:

    (a) $\frac{16.3521\,cm^2 - 1.448\,cm^2}{7.085\,cm}$ (b) $\left(92.12\,mL\right)\left(0.12\,g/mL\right) - 223.02\,g$

    (c) $1.41 \times 10^7\,g - 5.98 \times 10^6\,g$ (d) $\frac{1.41 \times 10^7\,g - 5.98 \times 10^6\,g}{6.35 \times 10^4\,cm^3}$
12. A laboratory instructor gives a sample of amino-acid powder to each of four students, I, II, III, and IV, and they weigh the samples. The true value is 8.72 g. Their results for three trials are

I: 8.72 g, 8.74 g, 8.70 g II: 8.56 g, 8.77 g, 8.83 g III: 8.50 g, 8.48 g, 8.51 g IV: 8.41 g, 8.72 g, 8.55 g
(a) Calculate the average mass from each set of data, and tell which set is the most accurate.
(b) Precision is a measure of the average of the deviations of each piece of data from the average value. Which set of data is the most precise? Is this set also the most accurate?
(c) Which set of data is both the most accurate and most precise?
(d) Which set of data is both the least accurate and least precise?

13. For the vectors $\vec{A}$ and $\vec{B}$ shown in Fig. 1, (I) use a scale drawing to find the magnitude and direction of (a) the vector sum $\vec{A}+\vec{B}$ and (b) the vector difference $\vec{A}-\vec{B}$. Use your answers to find the magnitude and direction of (c) $-\vec{A}-\vec{B}$ and (d)$\vec{B}-\vec{A}$.
(II) Find the x and y components of each vector and calculate (a) the magnitude and direction of $2\vec{A}-3\vec{B}+\vec{D}$, $\vec{A}+\vec{B}+\vec{C}+\vec{D}$, and $-2\vec{C}-5\vec{B}+4\vec{D}$;
(b) find a unit vector in the direction of $\vec{A}+\vec{B}$, $\vec{B}-\vec{A}$, and $\vec{A}+\vec{B}+\vec{C}+\vec{D}$.

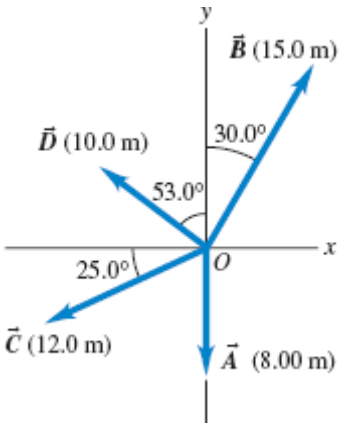


Fig. 1

14. A spelunker is surveying a cave. She follows a passage 180 m straight west, then 210 m in a direction 45^0 east of south, and then 280 m at 30^0 east of north. After a fourth unmeasured displacement, she finds herself back where she started. Use a scale drawing to determine the magnitude and direction of the fourth displacement.
15. A car travels north at 30.0 m/s for 10.0 min. It then travels south at 40.0 m/s for 20.0 min. What are the total distance the car travels and its displacement?
16. You ride your bike along a straight line from your house to a store 1000 m away. On your way back, you stop at a friend's house which is halfway between your house and the store.
    a) What is your displacement?
    b) What is the total distance traveled? After talking to your friend, you continue to your house. When you arrive back at your house,
    c) What is your displacement?
    d) What is the distance you have traveled?

17. A fellow student found in the performance data for his new car the velocity-versus-time graph shown in Fig. 2.

a) Find the average acceleration of the car during each of the segments I, II, and III.
b) What is the distance traveled by the car from t = 0 s to t = 6 s? from t = 6s to t = 12 s? from t = 12 s to t = 24 s?

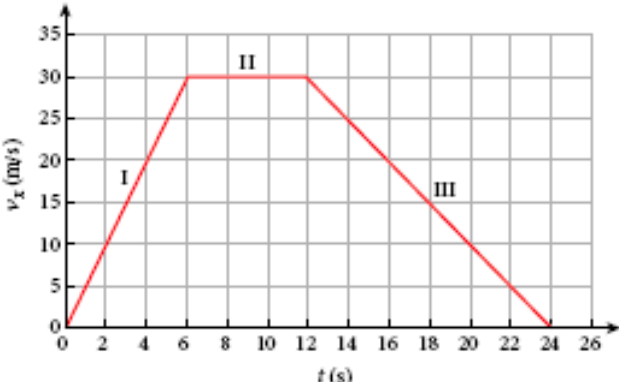


Fig. 2

18. You are on the roof of the physics building, 46.0 m above the ground (Fig. 3). Your friend, who is 1.80 m tall, is walking alongside the building at a constant speed of 1.20 m/s. If you wish to drop an egg on your friend's head, where should he be when you release the egg? Assume that the egg is in free fall.

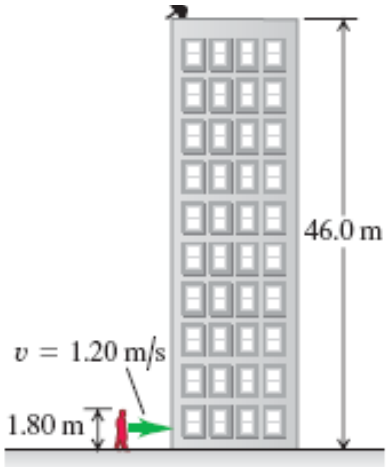
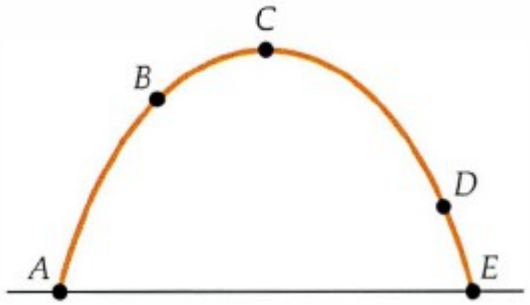


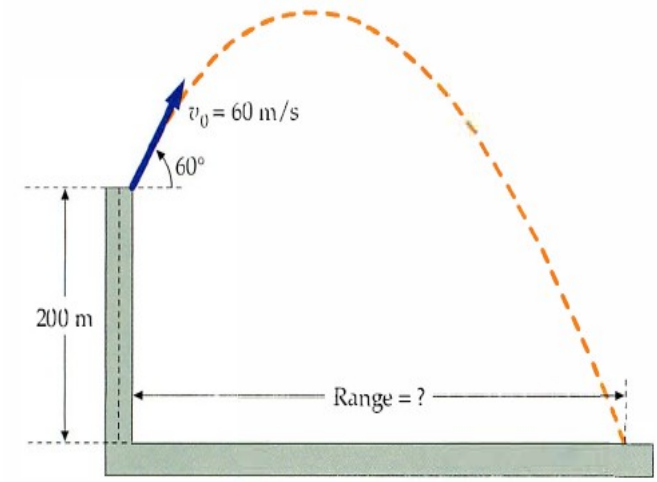
Fig. 3

19. Starting from a pillar, you run 200 m east (the + x-direction) at an average speed of 5.0 m/s, and then run 280 m west at an average speed of 4.0 m/s to a post. Calculate (a) your average speed from pillar to post and (b) your average velocity from pillar to post.
20. A car is stopped at a traffic light. It then travels along a straight road so that its distance from the light is given by $x(t) = bt^2 - ct^3$, where $b = 2.40 m/s^2$ and $c = 0.120 m/s^3$. (a) Calculate the average velocity of the car for the time interval t = 0 to t = 10.0 s. (b) Calculate the instantaneous velocity of the car at t = 0, t = 5.0 s, and t = 10.0 s. (c) How long after starting from rest is the car again at rest?
21. A car's velocity as a function of time is given by $v_x(t) = \alpha + \beta t^2$, where α = 3.00 m/s and β = 0.100 m/S3. (a) Calculate the average acceleration for the time interval t = 0 to t = 5.00 s. (b) Calculate the instantaneous acceleration for t = 0 and t = 5.00 s.
22. A stone is dropped from the roof of a high building. A second stone is dropped 1.0s later. How far apart are the stones when the second one has reached a speed of 40 m/s?
23. A falling stone takes 0.40sec to pass a window of 2.0m high. From what height above the window did the stone fall?
24. A ball is thrown vertically upward from the ground with a velocity of 30m/s. (a) how long will it take to rise to the highest point? (b) How high does the ball rise? (c) How long after projection will the ball have a velocity of 10m/s upward? A velocity of 10m/s downward? (d) When is the displacement of the ball zero? (e) When is the magnitude of the ball's velocity equal to half its velocity of projection? (f) When is the ball's displacement equal to half the maximum height to which it rises? (g) What is the magnitude and direction of the acceleration while the ball is moving upward? While moving downward? While at the highest point?

25. Referring to the motion described in the diagram shown below, (a) at which point(s) is the speed the greatest? (b) At which point(s) is the speed the lowest? (c) At which two points is the speed the same? Is the velocity the same at those points?



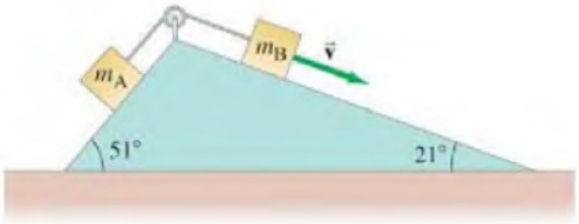
26. The radius of the earth's orbit around the sun (assumed to be circular) is 1.50 X 10^{8} km, and the earth travels around this orbit in 365 days. (a) What is the magnitude of the orbital velocity of the earth, in m/s? (b) What is the radial acceleration of the earth toward the sun, in m/s^2? (c) Repeat parts (a) and (b) for the motion of the planet Mercury (orbit radius = 5.79 X 10^{7} km, orbital period = 88.0 days).
27. A projectile, fired with unknown initial velocity, lands 20 s later on the side of a hill, 3000 m away horizontally and 450 m vertically above its starting point. (a) What is the vertical component of its initial velocity? (b) What is the horizontal component of its initial velocity?
28. A soccer player kicks a rock horizontally off a 40.0-m-high cliff into a pool of water. If the player hears the sound of the splash 3.00 s later, what was the initial speed given to the rock? Assume the speed of sound in air is 343 m/s.
29. A projectile is fired into the air from the top of a 200-m cliff above a valley as shown below. Its initial velocity is 60 m/s at 60° above the horizontal. Calculate (a) the maximum height, (b) the time required to reach its highest point, (c) the total time of flight, (d) the components of its velocity just before striking the ground, and (e) the horizontal distance traveled from the base of the cliff.



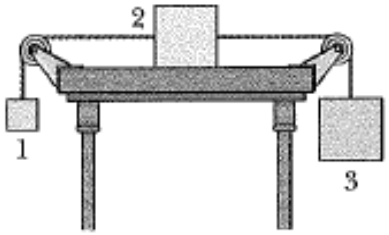
30. A projectile fired from the ground has a velocity $\vec{v}=(24\hat{i}-8\hat{j})m/s$ at a height of 9.8m. Find: a) the initial velocity; b) the maximum height.
31. An airplane diving at an angle of 36.9^0 below the horizontal drops a bag of sand from an altitude of 1200m. The bag is observed to strike the ground 6.0s after its release.
    (a) What is the speed of the plane?
    (b) How far does the bag travel horizontally during its fall?
    (c) What are the horizontal and vertical components of its velocity just before it strikes the ground?
32. (a) An object has an acceleration of 3 m / s^2 when the only force acting on it is F_0. What is its acceleration when this force is doubled? (b) A second object has an acceleration of 9 m/ s^2 under the influence of the force F_0. What is the ratio of the masses of the two objects? (c) If the two objects are glued together, what acceleration will the force F_0 produce?
33. A baseball player hits a ball with a bat. If the force with which the bat hits the ball is considered the action force, what is the reaction force?
34. Two crates, of mass 65 kg and 125 kg, are in contact and at rest on a horizontal surface, as shown below. A 650-N force is exerted on the 65-kg crate. If the coefficient of kinetic friction is 0.18, calculate (a) the acceleration of the system, and (b) the force that each crate exerts on the other. (c) Repeat with the crates reversed.



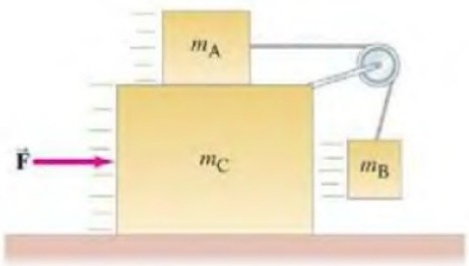
35. A box is given a push so that it slides across the floor. How far will it go, given that the coefficient of kinetic friction is 0.15 and the push imparts an initial speed of 3.5 m/s?
36. Two masses m_A = 2.0 kg and m_B = 5.0 kg are on inclines and are connected together by a string as shown below. The coefficient of kinetic friction between each mass and its incline is $\mu_k = 0.30$. If m_A moves up, and m_B moves down, determine (a) the tensions in the connecting string and (b) their acceleration.



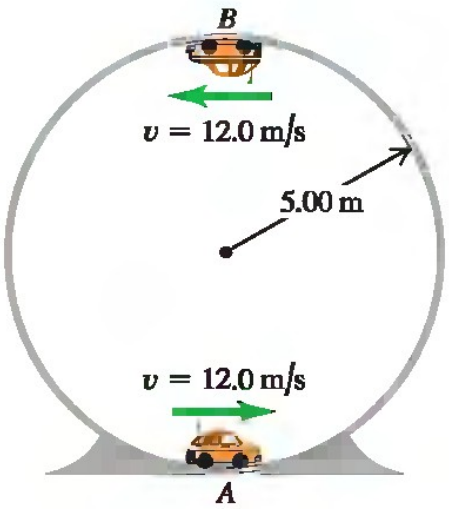
37. When the three blocks shown below are released from rest, they accelerate with a magnitude of 0.500 *m/s*^{2}. Block 1 has mass *M*, block 2 has *2M*, and block 3 has *2M*. What is the coefficient of kinetic friction between block 2 and the table?



38. Determine a formula for the magnitude of the force $\vec{F}$ exerted on the large block (m_C) in the figure shown below so that the mass m_A does not move relative to m_C. Ignore all friction. Assume m_B does not make contact with m_C.



39. A small remote-control car with mass 1.60 kg moves at a constant speed of v = 12.0 m/s in a vertical circle inside a hollow metal cylinder that has a radius of 5.00 m. (see the diagram). What is the magnitude of the normal force exerted on the car by the walls of the cylinder at (a) point A (at the bottom of the vertical circle) and (b) point B (at the top of the vertical circle)?



40. A small block of mass m is given an initial speed v_0 up a ramp inclined at angle θ to the horizontal. It travels a distance *d* up the ramp and comes to rest. (a) Determine a formula for the coefficient of kinetic friction between block and ramp. (b) What can you say about the value of the coefficient of static friction?