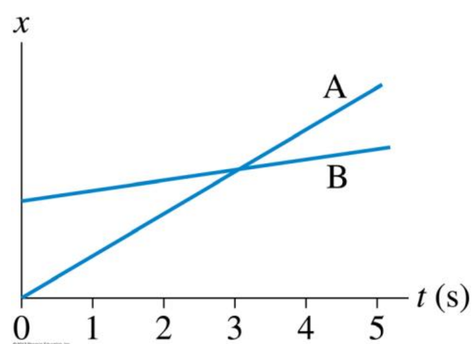
Addis Ababa University
College of Natural and Computational Sciences
Department of Physics
Phys 1011 Worksheet I

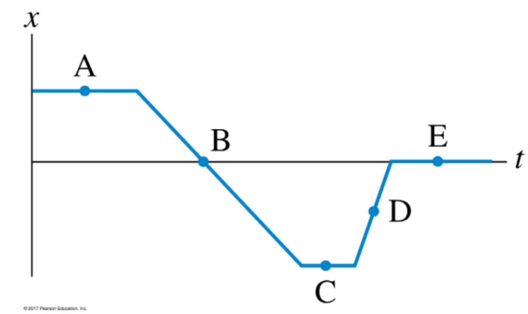
Conceptual Questions

1. Explain the difference between dimensions and units.
2. Can you add or subtract quantities with different units? Can you multiply or divide quantities with different units?
3. 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 $C = 0$?
4. 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?
5. 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.
6. 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*.



7. 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?
8. If the acceleration of an object is zero and its velocity is nonzero, what can you say about the motion of the object?

9. 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?



10. Under what conditions is average velocity equal to instantaneous velocity?
11. Under what conditions does the magnitude of the average velocity equal the average speed?
12. Can an object's acceleration be in the opposite direction to its motion? Explain.
13. Give examples of motion in which the directions of the velocity and acceleration vectors are (a) opposite, (b) the same, and (c) mutually perpendicular.
14. ''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.
15. 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?
16. 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.
17. 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) $v^2 = 2C_1 x$, (d) $x = C_1 \cos(C_2 t)$,
   (e) $v^2 = 2C_1 v - (C_2 x)^2$
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) $(92.12\ mL)(0.12\ g/mL) - 223.02\ g$

    (c) $1.41 \times 10^7 g - 5.98 \times 10^6 g$ (d) $\frac{1.41\times10^7 g - 5.98\times10^6 g}{6.35\times10^4 cm^3}$
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 $\vec{A}+\vec{B}+\vec{C}+\vec{D}$.

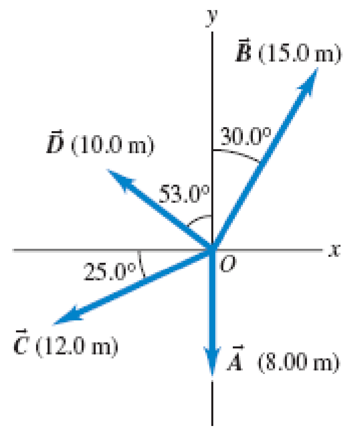


Fig. 1

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?

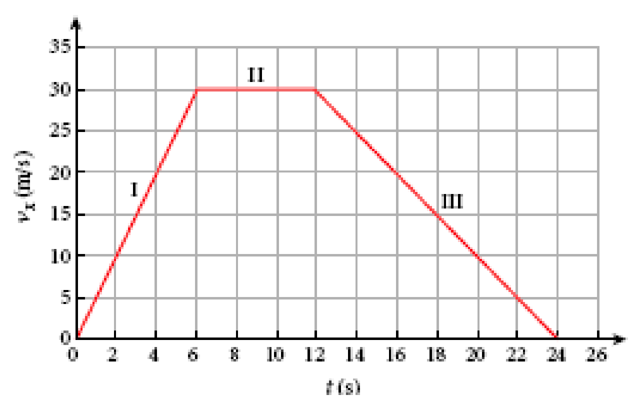


Fig. 2

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.

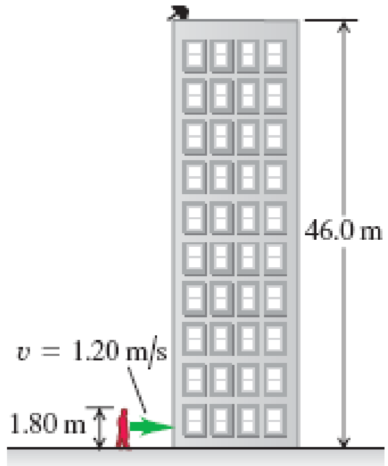
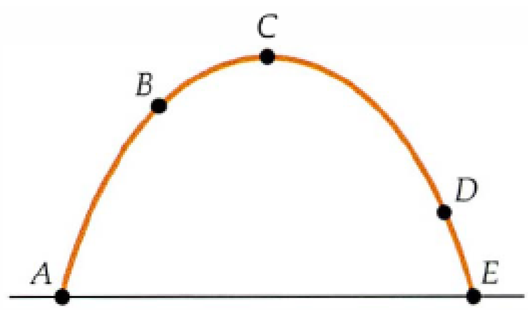


Fig. 3

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 $c = 0.120 m/s^3$. Calculate (a) the average velocity of the car for the time interval t = 0 to t = 10.0 s; (b) the instantaneous velocity of the car at t = 0, t = 5.0 s, and t = 10.0 s; (c) the average acceleration for the time interval t = 0 to t = 10.0 s; and (d) the acceleration at t = 5.0 s.
21. 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?
22. A falling stone takes 0.40sec to pass a window of 2.0m high. From what height above the window did the stone fall?
23. 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?

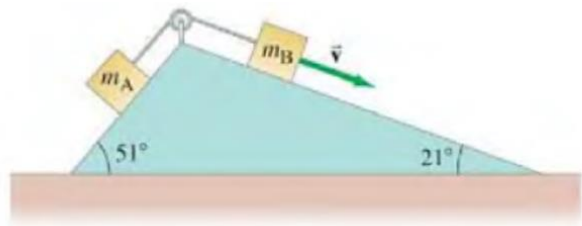


24. The radius of the earth's orbit around the sun (assumed to be circular) is 1.50×10^8 km, and the earth travels around this orbit in 365 days. (a) What is the magnitude of the orbital

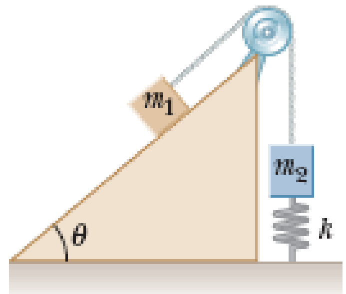
velocity of the earth, in m/s? (b) What is the radial acceleration of the earth toward the sun, in m/s^2? (c) Repeat parts (a) and (b) for the motion of the planet Mercury (orbit radius = 5.79×10^7 km, orbital period = 88.0 days).

25. 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?
26. 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.
27. 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?
28. (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?
29. 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.

30. 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?
31. 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.



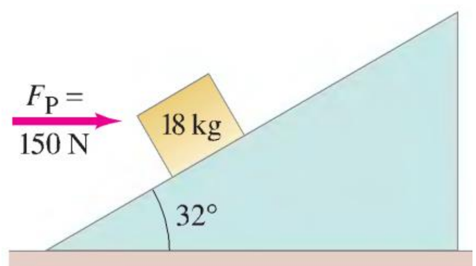
32. A 128.0 N carton is pulled up a frictionless baggage ramp inclined at $\mathbf{30^0}$above the horizontal by a rope exerting a 72.0 N pull parallel to the ramp's surface. If the carton travels 5.20 m along the surface of the ramp, calculate the work done on it by (a) the rope, (b) gravity, and (c) the normal force of the ramp. (d) What is the net work done on the carton? (e) Suppose that the rope is angled at $\mathbf{50^0}$above the horizontal, instead of being parallel to the ramp's surface. How much work does the rope do on the carton in this case?
33. A block of mass m_1= 20.0 kg is connected to a block of mass m_2= 30.0 kg by a massless string that passes over a light, frictionless pulley. The 30.0-kg block is connected to a spring that has negligible mass and a force constant of k= 250 N/m as shown below. The spring is unstretched when the system is as shown in the figure, and the incline is frictionless. The 20.0-kg block is pulled a distance h = 20.0 cm down the incline of angle $\boldsymbol{\theta} = \mathbf{40^0}$and released from rest. Find the speed of each block when the spring is again unstretched.



34. A certain spring stores 10.0 J of potential energy when it is stretched by 2.00 cm from its equilibrium position. (a) How much potential energy would the spring store if it were stretched an additional 2.00 cm? (b) How much potential energy would it store if it were compressed by 2.00 cm from its equilibrium position? (c) How far from the equilibrium position would you have to stretch the string to store 20.0 J of potential energy? (d) What is the force constant of this spring?
35. In the high jump, the kinetic energy of an athlete is transformed into gravitational potential energy without the aid of a pole. With what minimum speed must the athlete leave the ground in order to lift his center of mass 2.10 m and cross the bar with a speed of 0.70 m/s?
36. A spring of negligible mass has force constant $\boldsymbol{k = 1600\ N/m}$. (a) How far must the spring be compressed for $\mathbf{3.20}\boldsymbol{J}$ of potential energy to be stored in it? (b) You place the spring vertically with one end on the floor. You then drop a 1.20-kg book onto it from a height of 0.80 m above the top of the spring. Find the maximum distance the spring will be compressed.
37. A 25 kg child plays on a swing having support ropes that are 2.20 m long. A friend pulls her back until the ropes are $\mathbf{40^0}$from the vertical and releases her from rest. (a) What is the potential energy for the child just as she is released compared with the potential energy at the bottom of the swing? (b) How fast will she be moving at the bottom of the swing? (c) How much work does the tension in the ropes do as the child swings from the initial position to the bottom?
38. You throw a 20 N rock into the air from ground level and observe that, when it is 15.0 m high, it is travelling upward at 25.0m/s. Use the work–energy principle to find (a) the rock's speed just as it left the ground and (b) the maximum height the rock will reach.
39. A 72.0-kg swimmer jumps into the old swimming hole from a diving board 3.25 m above the water. Use energy conservation to find his speed just he hits the water (a) if he just holds his nose and

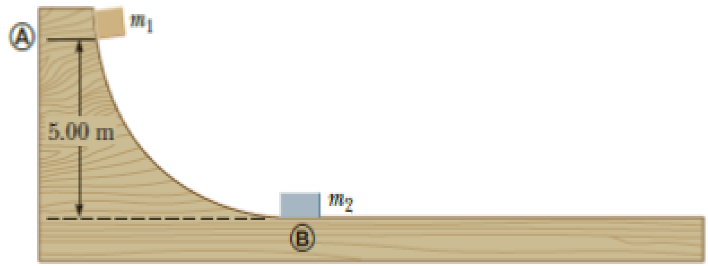
drops in, (b) if he bravely jumps straight up (but just beyond the board!) at 2.50m/s and (c) if he manages to jump downward at 2.50m/s.

40. A block of ice with mass 2.00 kg slides 0.750 m down an inclined plane that slopes downward at an angle of $\mathbf{36.9^0}$ below the horizontal. If the block of ice starts from rest, what is its final speed? You can ignore friction.
41. When a piece of wood is pressed against a spring and compresses the spring by 5.0 cm, the wood gains a maximum kinetic energy *K* when it is released. How much kinetic energy (in terms of *K*) would the piece of wood gain if the spring were compressed 10.0 cm instead?
42. A 6.0-kg box moving at 3.0 m/s on a horizontal, frictionless surface runs into a light spring of force constant 75 N/cm. Use the work-energy theorem to find the maximum compression of the spring.
43. (a) How much work is done by the horizontal force F_p = 150 N on the 18-kg block shown below when the force pushes the block 5.0 m up along the 32° frictionless incline? (b) How much work is done by the gravitational force on the block during this displacement? (c) How much work is done by the normal force? (d) What is the speed of the block (assume that it is zero initially) after this displacement? *Ans: a) 640J; b) -470J; c) 0; d) 4.3m/s*



44. Repeat Problem 16 assuming a coefficient of friction $\boldsymbol{\mu_k = 0.10}$.
45. Calculate the magnitude of the linear momentum for the following cases: (a) a proton with mass equal to 1.67 × 10-27 kg, moving with a speed of 5.00 × 106 m/s; (b) a 15.0-g bullet moving with a speed of 300 m/s; (c) a 75.0-kg sprinter running with a speed of 10.0 m/s; (d) the Earth (mass =5.98 × 1024 kg) moving with an orbital speed equal to 2.98 × 104 m/s.
46. A 0.280-kg volleyball approaches a player horizontally with a speed of 15.0 m/s. The player strikes the ball with her fist and causes the ball to move in the opposite direction with a speed of 22.0 m/s. (a) What impulse is delivered to the ball by the player? (b) If the player's fist is in contact with the ball for 0.060 0 s, find the magnitude of the average force exerted on the player's fist.

47. Consider a frictionless track as shown. A block of mass m1 = 5.00 kg is released from A. It makes a head-on elastic collision at B with a block of mass m2= 10.0 kg that is initially at rest. Calculate the maximum height to which m1rises after the collision.



48. Two blocks of masses m_1 and m_2 approach each other on a horizontal table with the same constant speed, v_0, as measured by a laboratory observer. The blocks undergo a perfectly elastic collision, and it is observed that m_1 stops but m_2 moves opposite its original motion with some constant speed, v. (a) Determine the ratio of the two masses, m_1/m_2. (b) What is the ratio of their speeds, v/v_0?

49. The mass of the Earth is 5.97 3 1024 kg, and the mass of the Moon is 7.35×10^{22} kg. The distance of separation, measured between their centers, is 3.84×10^8 m. Locate the center of mass of the Earth–Moon system as measured from the center of the Earth.