



General Physics I (Phys1011)

November 29, 2019

Worksheet: Chapter 2

Regular Semester I

Mekelle University
College of Natural and Computational Sciences
Department of Physics

Kinematics in One and Two Dimensions

- SET I: Can an object accelerate if its speed is constant? Can an object accelerate if its velocity is constant?
- SET II: 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.
- SET III: Explain whether or not the following particles have an acceleration: (a) a particle moving in a straight line with constant speed and (b) a particle moving around a curve with constant speed.
- SET IV: A projectile is launched on the Earth with some initial velocity. Another projectile is launched on the Moon with the same initial velocity. Neglecting air resistance, which projectile has the greater range? Which reaches the greater altitude? (Note that the free-fall acceleration on the Moon is about 1.6 m/s^2 .)
- SET V: What is the fundamental difference between the unit vectors $\hat{r}$ and $\hat{\theta}$ and the unit vectors $\hat{i}$ and $\hat{j}$?

- SET VI: A jet lands on an aircraft carrier at 140 mi/h (≈ 63 m/s). (a) What is its acceleration (assumed constant) if it stops in 2.0 s due to an arresting cable that snags the airplane and brings it to a stop? (b) If the plane touches down at position $x_i = 0$, what is the final position of the plane?
- SET VII: An object moving with uniform acceleration has a velocity of 12.0 cm/s in the positive x direction when its x coordinate is 3.00 cm. If its x coordinate 2.00 s later is -5.00 cm, what is its acceleration?
- SET VIII: A particle moves along the x axis according to the equation $x = 2.00 + 3.00t - 1.00t^2$, where x is in meters and t is in seconds. At $t = 3.00$ s, find (a) the position of the particle, (b) its velocity, and (c) its acceleration.
- SET IX: A fish swimming in a horizontal plane has velocity $\vec{v}_i = (4.00\hat{i} + 1.00\hat{j})$ m/s at a point in the ocean where the position relative to a certain rock is $\vec{r}_i = (10.0\hat{i} - 4.00\hat{j})$ m. After the fish swims with constant acceleration for 20.0 s, its velocity is $\vec{v} = (20.0\hat{i} - 5.00\hat{j})$ m/s. (a) What are the components of the acceleration? (b) What is the direction of the acceleration with respect to unit vector $\hat{i}$? (c) If the fish maintains constant acceleration, where is it at $t = 25.0$ s, and in what direction is it moving?
- SET X: Figure 1 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.

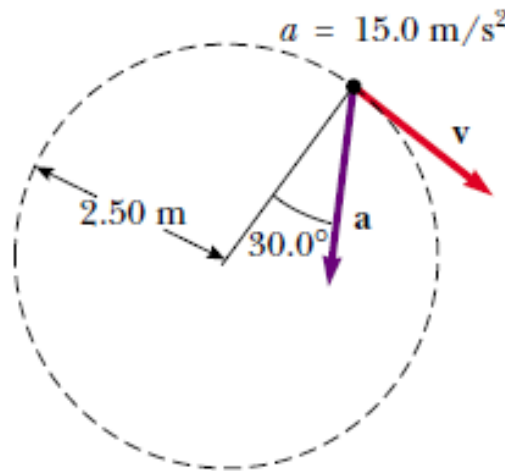


Figure 1: Circular motion

- SET XI: A particle starts from the origin with an initial velocity having an x component of 20 m/s and a y component of -15 m/s. The particle moves in the xy plane with an x component of acceleration only, given by $a_x = 4.0 \text{ m/s}^2$. Calculate the velocity at $\vec{r} = (150\hat{i} - 75\hat{j})$ m.

Particle Dynamics and Planetary Motion

- SET I: If a car is traveling westward with a constant speed of 20 m/s, what is the resultant force acting on it?
- SET II: What is wrong with the statement "Because the car is at rest, there are no forces acting on it"? How would you correct this sentence?
- SET III: At what position in its elliptical orbit is the speed of a planet a maximum? At what position is the speed a minimum?
- SET IV: Explain why it takes more fuel for a spacecraft to travel from the Earth to the Moon than for the return trip. Estimate the difference.
- SET V: If the gravitational force on an object is directly proportional to its mass, why don't objects with large masses fall with greater acceleration than small ones?
- SET VI: Two forces $\vec{F}_1$ and $\vec{F}_2$ act on a 5.00 kg object. If $\vec{F}_1 = 20.0$ N and $\vec{F}_2 = 15.0$ N, find the accelerations in (a) and (b) of Figure 2.

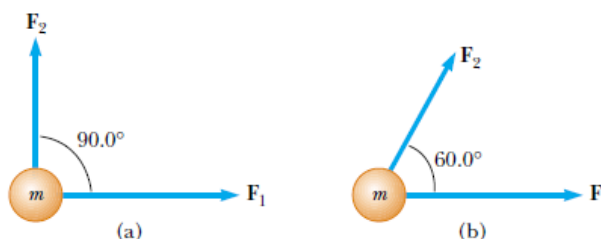


Figure 2: Force

- SET VII: Three forces acting on an object are given by $\vec{F}_1 = (-2.00\hat{i} + 2.00\hat{j})$ N, $\vec{F}_2 = (5.00\hat{i} - 3.00\hat{j})$ N, and $\vec{F}_3 = (-45.0\hat{i})$ N. The object experiences an acceleration of magnitude 3.75 m/s². (a) What is the direction of the acceleration? (b) What is the mass of the object? (c) If the object is initially at rest, what is its speed after 10.0 s? (d) What are the velocity components of the object after 10.0 s?
- SET VIII: When a falling meteoroid is at a distance above the Earth's surface of 3.00 times the Earth's radius, what is its acceleration due to the Earth's gravitation?
- SET IX: Io, a moon of Jupiter, has an orbital period of 1.77 days and an orbital radius of 4.22×10^5 km. From these data, determine the mass of Jupiter.
- SET X: The free-fall acceleration on the surface of the Moon is about one sixth of that on the surface of the Earth. If the radius of the Moon is about $0.250R_E$, find the ratio of their average densities, $\rho_{\text{Moon}}/\rho_{\text{Earth}}$.
- SET XI: An object is released from rest at an altitude h above the surface of the Earth. Show that its speed at a distance r from the Earth's center, where $R_E \leq r \leq R_E + h$, is given

by

$$v = \sqrt{2GM_E \left(\frac{1}{r} - \frac{1}{R_E + h} \right)}.$$

Work, Energy and Linear Momentum

- SET I: In an elastic collision between two particles, does the kinetic energy of each particle change as a result of the collision?
- SET II: Can the center of mass of an object be located at a position at which there is no mass?
- SET III: A force $\vec{F} = (6\hat{i} - 2\hat{j})$ N acts on a particle that undergoes a displacement $\Delta\vec{r} = (3\hat{i} + \hat{j})$ m. Find (a) the work done by the force on the particle and (b) the angle between $\vec{F}$ and $\Delta\vec{r}$.
- SET IV: A particle is attached between two identical springs on a horizontal frictionless table. Both springs have spring constant k and are initially unstressed. (a) If the particle is pulled a distance x along a direction perpendicular to the initial configuration of the springs, as in Figure 3, show that the force exerted by the springs on the particle is

$$\vec{F} = -2kx \left(1 - \frac{L}{\sqrt{x^2 + L^2}} \right) \hat{i}.$$

- (b) Determine the amount of work done by this force in moving the particle from $x = A$ to $x = 0$. (c) Show that the potential energy of the system is

$$U(x) = kx^2 + 2kL \left(L - \sqrt{x^2 + L^2} \right).$$

- (d) If the particle is pulled 0.500 m to the right and then released, what is its speed when it reaches the equilibrium point $x = 0$? (Assume that $L = 1.20$ m and $k = 40.0$ N/m.)

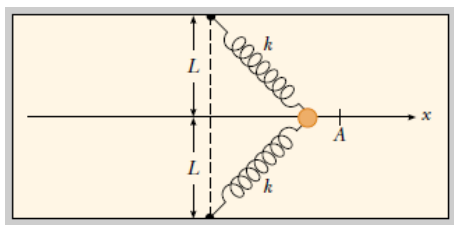


Figure 3: Elastic force

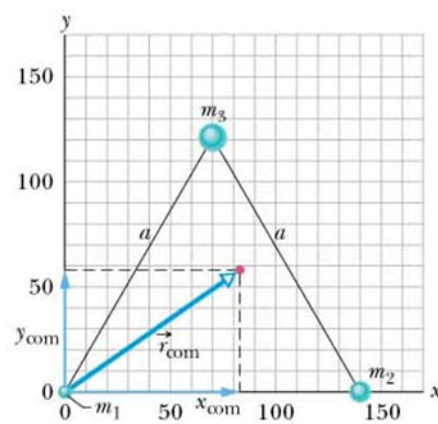


Figure 4: Center of Mass.

SET V: Three particles of masses $m_1 = 1.2\text{ kg}$, $m_2 = 2.5\text{ kg}$, and $m_3 = 3.4\text{ kg}$ form an equilateral triangle of edge length $a = 140\text{ cm}$. Where is the center of mass of this system? (Hint: m_1 is at $(0,0)$, m_2 is at $(140\text{ cm}, 0)$, and m_3 is at $(70\text{ cm}, 120\text{ cm})$, as shown in the figure 4.)

SET VI: A rod of length 30.0 cm has linear density (mass-per-length) given by

$$\lambda = 50.0\text{ g/m} + 20.0x\text{ g/m}^2,$$

where x is the distance from one end, measured in meters. (a) What is the mass of the rod? (b) How far from the $x = 0$ end is its center of mass?

SET VII: A 6.0-kg block initially at rest is pulled to the right along a horizontal surface by a constant horizontal force of 12 N . (a) Find the speed of the block after it has moved 3.0 m if the surfaces in contact have a coefficient of kinetic friction of 0.15 . (b) Suppose the force $\vec{F}$ is applied at an angle θ as shown in Figure 5(b). At what angle should the force be applied to achieve the largest possible speed after the block has moved 3.0 m to the right?

SET VIII: In a crash test, a car of mass $1.5 \times 10^3\text{ kg}$ collides with a wall and rebounds as in figure 6. The initial and final velocities of the car are $v_i = -15\text{ m/s}$ and $v_f = 2.6\text{ m/s}$, respectively. If the collision lasts for 0.15 s , find (a) the impulse delivered to the car due to the collision (b) the size and direction of the average force exerted on the car

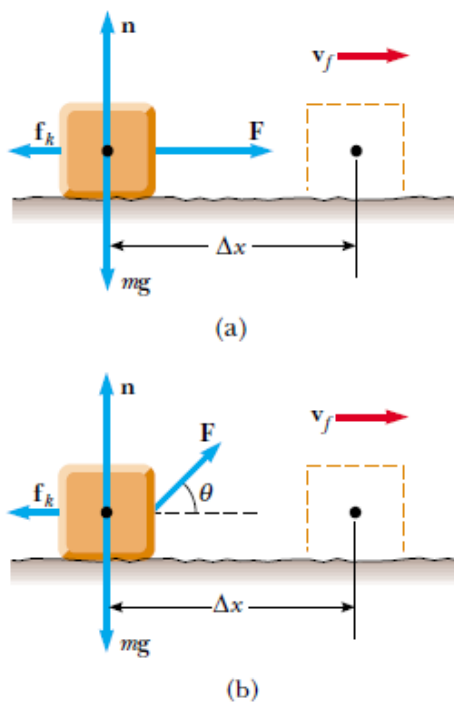


Figure 5: (a) A block pulled to the right on a rough surface by a constant horizontal force. (b) The applied force is at an angle θ to the horizontal.

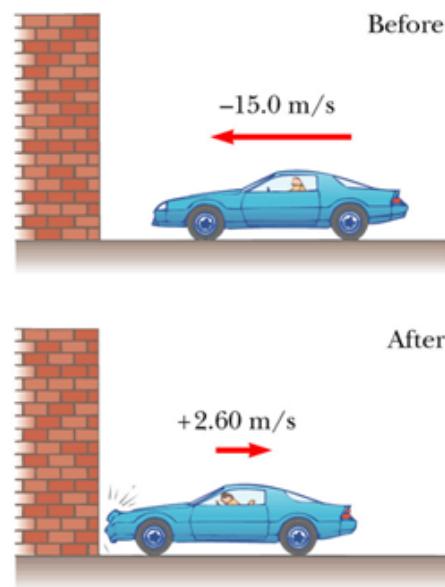


Figure 6: Collision

SET IX:

A neutron in a nuclear reactor makes an elastic head on collision with the nucleus of a carbon atom initially at rest. (a) What fraction of the neutron's kinetic energy is transferred to the carbon nucleus? (b) If the initial kinetic energy of the neutron is 1.60×10^{-13} J, find its final kinetic energy and the kinetic energy of the carbon nucleus after the collision. (The mass of the carbon nucleus is nearly 12.0 times the mass of the neutron.)