Pre-University Remedial Program
PHYSICS

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Chapters

1. Vectors (5hrs)
2. Kinematics (12hrs) (1D and 2D motion)
3. Angular motion (5hrs)
4. Dynamics (13hrs)
5. Work, energy and power (9hrs)
6. Oscillation and Waves (12hrs)
7. Heat and thermodynamics (10hrs)
8. Electrostatics (12hrs)
9. Electric current (13hrs)
10. Electromagnetic Induction and AC current (5hrs)

Direction

Objective: To make students ready to pass ESSLCE using active learning strategy.
- help to become the next university undergraduates

Method: revise basic concepts (lecture) and more focus on problem solving (activities)
- Choose exercises from a textbook (grades 9-12) and teaching through questioning and answering.
- Creating example model exam questions (previous year's exam) and instructing with questions and answers.

Evaluation: Every month you will have an examination (40 - 60%) and marked 30%. During test week, all students in the given department should receive the same test item at the same time.

* Class duration is from Megabit 07 - Sene 07, 2015 E.C
* Megabit 07 - Miyazia 07, Miyazia 07 - Ginbot 07, Ginbot 07 - Sene 07

1. Vectors (5hrs)

Based on grade 11^{th} textbook

Vector

A vector quantity is completely specified by a number (magnitude) and appropriate units plus a direction and also obeys the laws of vector addition. ($\vec{A}$)

Scalar

A scalar quantity is completely specified by a single value (magnitude) with an appropriate unit and has no direction.

Unit Vectors

A unit vector is a dimensionless vector having a magnitude of exactly 1. $\hat{A} = \frac{\vec{A}}{|\vec{A}|}$

Equality of Two Vectors

Two vectors are defined to be equal if they have the same magnitude and if they point in the same direction which are the same physical quantities. $10N, East = 10N, East$

Representing Vectors

Analytically - by bold face letters or letter with an arrow over its head (e.g. $\vec{A}$).
Graphically - by a ray where the length of it gives the magnitude and the arrow indicates the direction.

Types

Unit vector - e.g. $\hat{i}, \hat{j}, \hat{k}$
Position vector - tells the position of a body with respect to another point.
Collinear vectors - acting on the same line, which can be parallel or anti- parallel
Coplanar Vectors - act on the same plane.

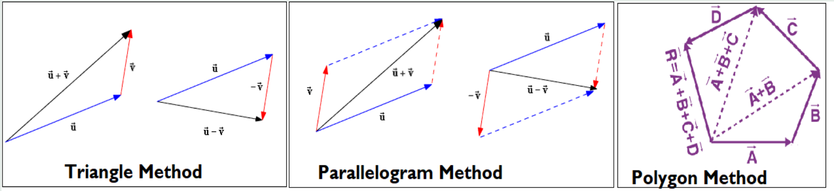
Resolution of vectors

Is the process of splitting a vector into components. (e.g. $(\vec{A}_x, \vec{A}_y)$)

1. Vectors

Vectors addition and subtraction

A. Graphical method of vector addition - (Triangle, Parallelogram, Polygon)



B. Analytical method of vector addition - component method, cosine law, sine law

- component $\vec{A} + \vec{B} = (A_x + B_x)i + (A_y + B_y)j$;
- cosine law $\vec{A} + \vec{B} = \sqrt{A^2 + B^2 + 2AB\cos\theta}$

Multiplication of vectors

A. Multiplying a vector by a scalar. (e.g. $\vec{A}$ multiplied by c ; $c\vec{A}$)

B. Multiplying a vector by another vector -

(i) scalar or dot product $\Rightarrow \vec{A}.\vec{B} = AB\cos\theta$

(ii) vector or cross product $\Rightarrow \vec{A} \times \vec{B} = AB\sin\theta$

1. Which of the following is a vector quantity?
   A. Mass B. Density C. Speed D. Temperature E. None of these
2. Which of the following is a scalar quantity?
   A. Speed B. Velocity C. Displacement D. Acceleration E. None of these
3. A plane traveling north at 200 m/s turns and then travels south at 200 m/s. The change in its velocity is:
   A. zero B. 200 m/s north C. 200 m/s south D. 400 m/s north E. 400 m/s south
4. Two forces one of $12N$ and another of $24N$, act on a body in such a way that they make an angle of 90^o with each other. Find the resultant of the two force.
5. What is the unit vector in the direction of vector $\vec{A} = 3i + 4j + 2k$?

6. If $\vec{A} = \beta(4i + 3j)$ determine the constant β that makes $\vec{A}$ is a unit vector.
7. If $\vec{A} - \vec{B} = 3\vec{C}$ and $\vec{A} + \vec{B} = 5\vec{C}$, where $\vec{C} = 2i + 4j$ then, what are the values of $\vec{A}$ and $\vec{B}$?
8. Suppose $\vec{A} = 3i - 2j$ and $\vec{B} = -i - aj$ are two vectors in xy plane what is the value of a such that $\vec{A} + \vec{B} = 2i$?
9. Suppose $\vec{A} = 3i - 2j$, $\vec{B} = -i - 4j$ and $\vec{C}$ are vectors in xy plane with the property $\vec{A} + \vec{B} - \vec{C} = 0$, find the unit vector along $\vec{C}$.
10. Two cars A and B are moving along a straight road in the same direction with velocities of $25km/h$ and $30km/h$, respectively. Find the velocity of car B relative to car A.

11. Two non zero vectors A and B have equal magnitudes. For the magnitude of $A+B$ to be 3 times larger than the magnitude of $A-B$, What must be the angle between A and B?
12. If $|\vec{A}\times\vec{B}| = \sqrt{3}\vec{A}.\vec{B}$, then what is the value of $|\vec{A}+\vec{B}|$
13. The vectors $2i+j+k$ is perpendicular to $i-4j+\lambda k$. What is the value of λ?
14. What is the angle between $\vec{A} = ai + a\sqrt{3}j$ and $\vec{B} = a\sqrt{3}i + aj$?
15. Suppose $\vec{A} = 3i-2j+k$, $\vec{B} = -i-4j+3k$ and $\vec{C}$ is a vector laying along x-axis with the property that $\vec{A}.(\vec{B}+\vec{C}) = 0$. Then, what is vector $\vec{C}$?

16. If $\vec{A} = 8i + j - 2k$ and $\vec{B} = 5i - 3j + k$. Find $\vec{A}.\vec{B}$ and $\vec{A} \times \vec{B}$.
17. The vector $-\vec{A}$ is:
A. greater than $\vec{A}$ in magnitude B. less than $\vec{A}$ in magnitude
C. in the same direction as $\vec{A}$ D. in the direction opposite to $\vec{A}$
18. Let $\vec{V} = (2.00m)i + (6.00m)j - (3.00m)k$. The magnitude of $\vec{V}$ is:
A. 5.00 m B. 5.57 m C. 7.00 m D. 7.42 m E. 8.54 m
19. Let $\vec{A} = (2m)i + (6m)j - (3m)k$ and $\vec{B} = (4m)i + (2m)j + (1m)k$. Then $\vec{A}.\vec{B}$ is
A. $(8m)i + (12m)j - (3m)k$ B. $(12m)i - (14m)j - (20m)k$
C. $23m^2$ D. $17m^2$
20. The value of $i.(j \times k)$ is:
A. zero B. $+1$ C. -1 D. 3 E. $\sqrt{3}$

21. The angle between the vectors $(i + j)$ and $(j + k)$ is
A. 30^o B. 60^o C. 45^o D. 90^o

22. If the resultant of two vectors having magnitudes of 6 and 3 is 9, then the dot product of the two vectors is
A. 6 B. 3 C. 9 D. 18

23. If the angle between vector $\vec{A}$ and $\vec{B}$ is θ, the value of the product $(\vec{B} \times \vec{A}).\vec{A}$ is equal to
A. 0 B. $BA^2 \sin\theta$ C. $BA^2 \cos\theta$ D. $BA^2 \sin\theta \cos\theta$

24. Given the displacement vectors $\vec{A} = (3i - 4j + 4k)m$ and $\vec{B} = (2i + 3j - 7k)m$, find the magnitudes of the vectors (a) $\vec{C} = \vec{A} + \vec{B}$ and (b) $\vec{D} = 2\vec{A} - \vec{B}$

25. Two vectors $\vec{A}$ and $\vec{B}$ have precisely equal magnitudes. For the magnitude of $\vec{A} + \vec{B}$ to be 100 times larger than the magnitude of $\vec{A} - \vec{B}$, what must be the angle between them?

26. Vectors $\vec{A}$ and $\vec{B}$ have equal magnitudes of 5.00. The sum of $\vec{A}$ and $\vec{B}$ is the vector $6j$. Determine the angle between $\vec{A}$ and $\vec{B}$.

Motion in 1D

- Position: Defined in terms of a frame of reference: x or y axis in 1D.
- The object's position is its location with respect to the frame of reference.
- Distance: length of a path followed by a particle.(scalar)
- Displacement: Change from position x_1 to x_2 during a time interval. (vector) $\Delta x = x_2 - x_1$
- Average velocity: Ratio of the displacement Δx that occurs during a particular time interval Δt to that interval. $\vec{v}_{av} = \frac{\Delta x}{\Delta t}$
- The slope of a straight line connecting 2 points on an x-versus-t plot is equal to the average velocity during that time interval.
- Average speed: Total distance covered in a time interval. $v_{av} = \frac{S}{\Delta t}$
- The instantaneous velocity indicates what is happening at every point of time.
- When the velocity is constant, the average velocity over any time interval is equal to the instantaneous velocity at any time.
- Instantaneous speed: Magnitude of the instantaneous velocity

2. Kinematics

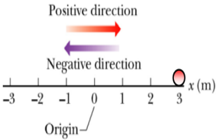
Position is a vector quantity.

Position has both a direction and magnitude.

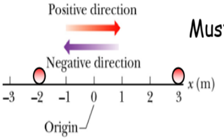
Position has units of [Length]: *meters.*

Must define:

- $x = 0$ some position (Origin)
- positive direction for x



$x = 3$ m



Must define: $t = 0$

Displacement: $\Delta x = x_2 - x_1$

$x_1 =$ 3 m

$x_2 =$ -2 m

$\Delta x =$ -5 m

Displacement is a change of position in time.

It is a vector quantity.

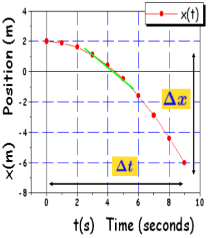
It has both a direction and magnitude.

It has units of [Length]: *meters*.

Motion in 1D

- Average acceleration: Ratio of a change in velocity $\Delta\vec{v}$ to the time interval Δt in which the change occurs.
  $\vec{a}_{av} = \frac{\Delta\vec{v}}{\Delta t} = \frac{\vec{v}_f - \vec{v}_i}{\Delta t}$
- The average acceleration in a v vs t plot is the slope of a straight line connecting points corresponding to two different times
- Instantaneous acceleration: Limit of the average acceleration as Δt approaches zero.
- When an object's velocity and acceleration are in the same direction (same sign), the object is speeding up.
- When an object's velocity and acceleration are in the opposite direction, the object is slowing down.
- Motion with constant accelerations is called uniformly accelerated motion, with equations UAME
  $v_f = v_i + at$
  $s = 0.5(v_f + v_i)t$
  $s = v_i t + 0.5at^2$
  $v_f^2 = v_i^2 + 2as$

Velocity



Average velocity

$$v_{\text{avg}} = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1}$$ =-8/9 m/s ≈ -0.9 m/s

Average speed

$$s_{\text{avg}} = \frac{\text{total distance}}{\Delta t}$$ =8/9 m/s ≈ 0.9 m/s

Instantaneous velocity

$$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

Velocity is the rate of change of position

Acceleration

- Average acceleration

$$a_{\text{avg}} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{\Delta v}{\Delta t}$$

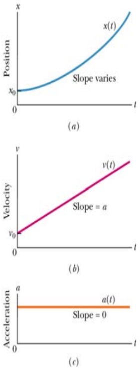
- Instantaneous acceleration

$$a = \frac{dv}{dt}$$

- Constant acceleration

$$v = v_0 + at$$

$$x - x_0 = v_0 t + \frac{1}{2}at^2$$



Motion in 2D

- Projectile motion is a form of motion experienced by an object or particle (a projectile) that is projected near Earth's surface and moves along a curved path under the action of gravity only (in particular, the effects of air resistance are passive and assumed to be negligible).
- Let the projectile be launched with an initial velocity u, which can be expressed as the sum of horizontal and vertical components as follows:
  $u = u_x + u_y = u\cos(\theta) + u\sin(\theta)$
  where θ is the initial launch angle from the horizontal.
- The horizontal component of the velocity of the object remains unchanged throughout the motion. $v_x = u\cos(\theta)$
- The vertical component of the velocity changes linearly, because the acceleration due to gravity is constant. $v_y = u\sin(\theta) - gt$
- At any time t, the projectile's horizontal and vertical displacement are:
  $x = ut\cos(\theta)$ and $y = ut\sin(\theta) - \frac{1}{2}gt^2$
- The time to reach the maximum height(H) is $t_H = \frac{u\sin(\theta)}{g}$
- The maximum height of projectile become $H = \frac{u^2\sin^2(\theta)}{2g}$

Motion in 2D

- Total time of flight become:
  $t_f = \frac{2u\sin(\theta)}{g}$
- From the horizontal displacement the maximum distance of projectile:
  $R = u\cos(\theta)t_f = \frac{2u^2\cos(\theta)\sin(\theta)}{g} = \frac{u^2\sin(2\theta)}{g}$
- Uniform circular motion is the motion of a particle moving at a constant speed on a circle. The velocity vector of the particle is constant in magnitude, but it changes in direction.
- Centripetal force and centripetal acceleration act towards the center of the circle. $F_c = \frac{mv^2}{r}$ and $a_c = \frac{v^2}{r}$, where a_c and F_c are centripetal acceleration and centripetal force, m is mass of the object, v is velocity of the object and r is radius of the curved path.
- Imagine the maximum frictional force between the road and the treys of a certain car is $6500N$. The mass of the car is $1200kg$ and the bend has a radius of $85m$. Determine the maximum speed at which the car can take the bend?

1. A body sets off from rest with a constant acceleration of $8\,m/s^2$. What distance will it have covered after $3\,s$.
2. A car traveling at $5\,m/s$ starts to speed up. After $3\,s$ its velocity has increased to $11\,m/s$. What is its acceleration? and What distance does it travel while speed up?
3. A motorist traveling at $18\,m/s$ approaches traffic lights. When he is $30\,m$ from the stop line, they turn red. It takes $0.7\,s$ before he can react by applying the brakes. The car slows down at a rate of $4.6\,m/s^2$. How far from the stop line will he come to rest and on which side of it.

1. A body sets off from rest with a constant acceleration of $8\,m/s^2$. What distance will it have covered after $3\,s$.
   Solution
   $S = v_i t + 1/2 \times at^2 = 1/2 \times (8\,m/s^2)(3s)^2 = 36m$
2. A car traveling at $5\,m/s$ starts to speed up. After $3\,s$ its velocity has increased to $11\,m/s$. What is its acceleration? and What distance does it travel while speed up?
   Solution
   $a = \frac{v_f - v_i}{t} = 2\,m/s^2$
   $s = v_i t + 1/2 \times at^2 = (5\,m/s) * 3s + 1/2 \times 2\,m/s^2 (3\,s)^2$
   $s = 15m + 9m = 24m$
3. A motorist traveling at $18\,m/s$ approaches traffic lights. When he is $30\,m$ from the stop line, they turn red. It takes $0.7\,s$ before he can react by applying the brakes. The car slows down at a rate of $4.6\,m/s^2$. How far from the stop line will he come to rest and on which side of it.
   Solution
   $s = v_i t + 1/2 \times at^2 = (18\,m/s) \times 0.7s + 1/2 \times 4.6\,m/s^2 \times (0.7\,s)^2 = 13.7270\,m$
   Distance from stop line is $30m - 13.7270m = 16.2730\,m$

4. A falling stone accelerates at a constant rate of $10 m/s^2$. It is dropped from rest down a deep well, and $3s$ later a splash is heard as it hits the water below.
   (a) how fast will it be moving as it hits the water?
   (b) what will be its average speed over the three seconds?
   (c) how deep is the well?
5. A car moving with an initial velocity of $25\, m/s$ north has a constant acceleration of $3\, m/s^2$ south. After $6\, sec$ its velocity will be:
   A. 7 m/s north B. 7 m/s south C. 43 m/s north D. 20 m/s north
6. A baseball is thrown vertically into the air. Acceleration of the ball at its highest point is:
   A. zero B. g, down C. g, up D. 2g, down E. 2g, up
7. A ball is hit straight up and is caught by person 2 se later. The maximum height of the ball during this travel is
   A. 4.9m B. 7.4m C. 9.8m D. 12.6m E. 19.6m

6. A footballer kicks a ball on horizontal ground giving it an initial velocity of 25 m/s at an angle of 30^o to the horizontal.
   (a) Where will the ball be 1.2 seconds after it is kicked?
   (b) What will be the greatest height reached by the ball?
   (c) Where will the ball land?
7. A boy throws a ball from the building into the Tana Lake. When the ball leaves his hand it travels horizontally at a velocity of 20 m/s.
   (a) How long will it take the ball to reach the lake, a distance $12m$ meters below?
   (b) How far from the bottom of the building will it be when it enters the lake?
   (c) What will its vertical velocity be when it hits the water?

10. A military helicopter is traveling horizontally at 30 m/s at a height of 120 meters above the surface ground when it releases a package to the survivors.
(a) How long will it take the package to reach the ground?
(b) Calculate the vertical velocity of the package when it reaches the ground.

11. Tesema throws a ball into the air. Its velocity at the start is $18m/s$ at an angle of 37^o to the ground. ($sin(37^o) = 0.6$ and $cos(37^o) = 0.8$))
(a) Work out the velocity of the ball as it lands.
(b) Work out the range of the ball.

12. A geostationary satellite for communications seems to be in a fixed spot above the equator because it has the same angular velocity as the Earth.
(a) What is the period of the satellite?
(b) Since satellite orbital radius is $4.2 \times 10^4 m$, then find the acceleration due to gravity at this height? ($G = 6.67 \times 10^{-11} Nm^2/kg^2 \quad M_E = 6 \times 10^{24}\, kg$)

13. An object moving with uniform acceleration has a velocity of $12m/s$ in the positive x direction when its x coordinate is $3cm$. If its x coordinate 2 sec later is $-5cm$. What is its acceleration?

14. A cart on air track is moving at $0.5m/s$ when the air is suddenly turned off. The cart comes to rest after traveling $1m$. The experiment is repeated, but now the cart is moving at $1m/s$ when the air is turned off. How far does the cart travel before coming to rest? (for both experiments acceleration is the same)

15. A body moving with constant acceleration covers the distance between two points $60m$ a part in $5sec$. Its velocity as it passes the second point is $15m/s$. What is the acceleration?

16. If a long distance jumper athlete leaves the ground at an angle of 37^o above the horizontal at a speed of $10m/s$, how far does he jump in the horizontal direction? $(sin(37^o) = 0.6 \quad \text{and} \quad cos(37^o) = 0.8))$

17. A ball rolls off the edge of a horizontal table top $4m$ high. It strikes the floor at a point $5m$ horizontally away from the edge of the table. How long was the ball in the air in second?

18. A car and a bus move with velocities given by $V_c = (3i - 2j)$ and $V_b = (-5i - 4j)$ m/s, respectively, according to an observer on the ground. What is the velocity of the bus according to the car driver?
19. A body starts rest and moves with a uniform acceleration $10\,m/s^2$ in the first $10\,sec$. During the next $10\,sec$, it moves with uniform velocity. The total distance covered by the body is
20. A body projected vertically upward with a velocity u returns to the starting point in $4\,sec$. What is the value of u?

21. If the initial velocity of a projectile be doubled, keeping the angle of projection the same, the maximum height reached by it will be
A. be halved B. be doubled C. be quadrupled D. remain the same

22. A soccer player kicks a rock horizontally off a 40 m high cliff into a pool of water. If the player hears the sound of the splash 3 s later, what was the initial speed given to the rock? Assume the speed of sound in air is 343 m/s

23. A particle initially located at the origin has an acceleration of $\vec{a} = 3j\ m/s^2$ and an initial velocity of $\vec{a} = 5i\ m/s$. Find (a) the vector position and velocity of the particle at any time t and (b) the coordinates and speed of the particle at $t = 2\,s$.

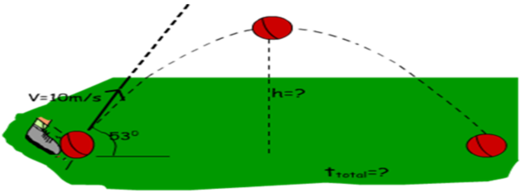
24. The area under a velocity-time graph represents:
A. acceleration B. speed C. displacement D. change in velocity

25. Two projectiles are in flight at the same time. The acceleration of one relative to the other:
A. is always $9.8\,m/s^2$ B. can be as large as $19.8m/s^2$ C. can be horizontal D. is zero

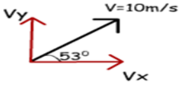
26. A boy kicks the ball and ball does projectile motion with an angle of 53^o to horizontal. Its initial velocity is $10\,m/s$, find the maximum height it can reach, horizontal displacement and total time required for this motion.
$(sin53^o = 0.8 \quad and \quad cos53^o = 0.6)$

27. What is the centripetal acceleration of the Earth as it moves in its orbit around the Sun? $(r_{ES} = 1.5 \times 10^{11}\,m)$

Solution: Q.26



First we seperate our velocity into its components to make problem simple.



$Vx = V.\cos 53^{\circ} = 10.0,6 = 6m/s$
$Vy = V.\sin 53^{\circ} = 10.0,8 = 8m/s$

In vertical;

$V = Vo - g.t$
$0 = 8 - 10.t$
$t = 0,8s$
$t_{total} = 1,6s$

0,8s is the time required only for the half of the motion. Thus, we multiply it with two for total time.

$h = \frac{1}{2} g.t^2$

$h = \frac{1}{2} 10.(0,8s)^2 = 3,2m$

We use 0.8s time because we just consider vertical motion.

In horizontal;

$X = V.t$
$X = 6.1,6 = 9,6m$

Question 28

28. 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.

28. 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.

Analyze: With the position given by $x = 2.00 + 3.00t - t^2$, we can use the rules for differentiation to write expressions for the velocity and acceleration as functions of time:

$$v_x = \frac{dx}{dt} = \frac{d}{dt}\left(2 + 3t - t^2\right) = 3 - 2t \qquad \text{and} \qquad a_x = \frac{dv}{dt} = \frac{d}{dt}(3 - 2t) = -2$$

Now we can evaluate x, v, and a at $t = 3.00$ s.

(a) $x = 2.00 + 3.00(3.00) - (3.00)^2 = 2.00$ m

(b) $v_x = 3.00 - 2(3.00) = -3.00$ m/s

(c) $a_x = -2.00$ m/s^2

Question 29

29 · A person walks first at a constant speed of 5.00 m/s along a straight line from point Ⓐ to point Ⓑ and then back along the line from Ⓑ to Ⓐ at a constant speed of 3.00 m/s. (a) What is her average speed over the entire trip? (b) What is her average velocity over the entire trip?

29 · A person walks first at a constant speed of 5.00 m/s along a straight line from point Ⓐ to point Ⓑ and then back along the line from Ⓑ to Ⓐ at a constant speed of 3.00 m/s. (a) What is her average speed over the entire trip? (b) What is her average velocity over the entire trip?

(a) The average speed during any time interval is equal to the total distance of travel divided by the total time:

$$\text{average speed} = \frac{\text{total distance}}{\text{total time}} = \frac{d_{AB} + d_{BA}}{t_{AB} + t_{BA}}$$

But $d_{AB} = d_{BA,}$ $t_{AB} = d/v_{AB},$ and $t_{BA} = d/v_{BA}$

so $$\text{average speed} = \frac{d+d}{(d/v_{AB}) + (d/v_{BA})} = \frac{2(v_{AB})(v_{BA})}{v_{AB} + v_{BA}}$$

and $$\text{average speed} = 2\left[\frac{(5.00\ \text{m/s})(3.00\ \text{m/s})}{5.00\ \text{m/s} + 3.00\ \text{m/s}}\right] = 3.75\ \text{m/s}$$

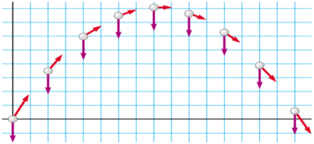
(b) The average velocity during any time interval equals total displacement divided by elapsed time.

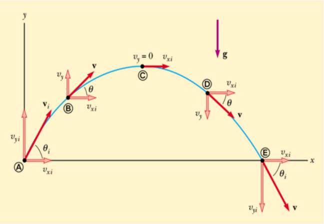
$$v_{x,avg} = \frac{\Delta x}{\Delta t}$$

Since the walker returns to the starting point, $\Delta x = 0$ and $v_{x,avg} = 0$

Projectile motion

A projectile moves with constant velocity along the horizontal direction and with constant acceleration (g) along the downward vertical direction. The path of a projectile is a parabola.





- For the motion of a projectile, which is launched from the origin at $t_i = 0$ with a positive y-component of velocity and returns to the initial horizontal level:

Position coordinates:

$$x_f = v_{xi}\, t = (v_i \cos\theta_i)\, t$$

$$y_f = (v_i \sin\theta_i)\, t - \tfrac{1}{2} g t^2$$

Velocity components:

$$v_x = v_i \cos\theta_i = \text{constant}$$

$$v_y = v_i \sin\theta_i - g t$$

Maximum height:

$$h = \frac{v_i^2 \sin^2\theta_i}{2g}$$

Range: The range is maximum when $\theta_i = 45°$

$$R = \frac{v_i^2 \sin 2\theta_i}{g}$$

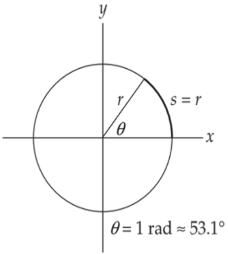
- The rotational motion describes the relationships between the angle of rotation, position, angular velocity, angular acceleration, and time.
- **Angular displacement** of a body is the angle (in radians, degrees or revolutions) through which a point revolves around a centre or a specified axis in a specified sense.
- For any curved path the angular displacement is given by
  $\Delta\theta = \theta_2 - \theta_1$
- One radian is the angle subtended at the center of a circle by an arc that is equal in length to the radius of the circle.
  $1 radian = 57.3^o = \frac{180}{\pi}$
- The angular velocity (ω) of the object is the change of angle with respect to time. It is the rate of change of the angle subtended.
- The average angular velocity is the angular displacement divided by the time interval:
  $\omega = \frac{\theta_2 - \theta_1}{t} = \frac{\Delta\theta}{t}$
  For one complete cycle: $\omega = \frac{2\pi radian}{T}$, where T is the period.
- Tangential velocity (v) is equal to the angular velocity times the radius: $v = \omega r$

- The **Tangential acceleration** is the change in tangential velocity divided by the time taken
  $a_t = \frac{\Delta v}{t} = \frac{v_2 - v_1}{t}$
- The **Centripetal acceleration** is an acceleration towards the center of a circle and obtained from the tangential velocity and radius of the circle
  $a_v = \frac{v^2}{r} = r\omega^2$
- The **angular acceleration** (α) of the object is the change of the angular velocity with respect to time:
  $\alpha = \frac{\Delta\omega}{t} = \frac{\omega_2 - \omega_1}{t}$
- The equations of constant angular acceleration are
  $\omega_f = \omega_i + \alpha t,$
  $\theta = \frac{1}{2}(\omega_f + \omega_i)t,$
  $\theta = \omega_i t + \frac{1}{2}\alpha t^2,$
  $\theta = \omega_f t - \frac{1}{2}\alpha t^2,$
  $\omega_f^2 = \omega_i^2 + 2\alpha\theta,$
  where, θ is angular displacement, ω_f is final angular velocity, ω_i is initial angular velocity, α is angular acceleration, and t is the time taken.

EQUATIONS AND CONCEPTS

The **arc length**, s, is the distance traveled by a particle which moves along a circular path of radius r. *As the particle moves along the arc, the radius line sweeps out an angle θ (measured counterclockwise relative to a reference line).*

$$s = r\theta \qquad 10.1a$$



The **angular displacement** θ is the ratio of two lengths (arc length to radius) and hence is a dimensionless quantity. However, it is common practice to refer to the angle theta as being in units of radians. In calculations, the relationship between radians and degrees is shown to the right.

$$\theta(\text{rad}) = \frac{\pi}{180^\circ}\theta(\text{deg})$$

The **average angular speed** ω_{avg} of a particle or body rotating about a fixed axis equals the ratio of the angular displacement $\Delta\theta$ to the time interval Δt, where θ is measured in radians. *In the case of a rigid body, $\Delta\theta$ is associated with the entire body as well as with each element of the body.*

$$\omega_{avg} \equiv \frac{\theta_f - \theta_i}{t_f - t_i} = \frac{\Delta\theta}{\Delta t} \qquad (10.2)$$

The **instantaneous angular speed** ω is defined as the limit of the average angular speed as Δt approaches zero. *ω is considered positive when θ is increasing counterclockwise.*

$$\omega \equiv \lim_{\Delta t \to 0} \frac{\Delta\theta}{\Delta t} = \frac{d\theta}{dt} \qquad (10.3)$$

The **average angular acceleration** α_{avg} of a rotating body is defined as the ratio of the change in angular velocity to the time interval Δt during which the change occurs.

$$\alpha_{avg} \equiv \frac{\omega_f - \omega_i}{t_f - t_i} = \frac{\Delta\omega}{\Delta t} \qquad (10.4)$$

The **instantaneous angular acceleration** equals the limit of the average angular acceleration as Δt approaches zero. *When a rigid object is rotating about a fixed axis, every element of the object rotates through the same angle in a given time interval and has the same angular velocity and the same angular acceleration.*

$$\alpha \equiv \lim_{\Delta t \to 0} \frac{\Delta\omega}{\Delta t} = \frac{d\omega}{dt} \tag{10.5}$$

The **equations of rotational kinematics** apply when a particle or body rotates about a fixed axis with ***constant angular acceleration***.

$$\omega_f = \omega_i + \alpha t \tag{10.6}$$

$$\theta_f = \theta_i + \omega_i t + \tfrac{1}{2}\alpha t^2 \tag{10.7}$$

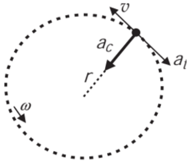
$$\omega_f^2 = \omega_i^2 + 2\alpha(\theta_f - \theta_i) \tag{10.8}$$

$$\theta_f = \theta_i + \tfrac{1}{2}(\omega_i + \omega_f)t \tag{10.9}$$

The values of **tangential speed and tangential acceleration** are proportional to the corresponding angular values. All points on an object rotating about a fixed axis have the same values of angular speed and angular acceleration. However, the corresponding values of tangential speed and acceleration depend on the radial distance from the axis of rotation. The figure shows a disk rotating counterclockwise with negative angular acceleration about an axis through the center.

$$v = r\omega \tag{10.10}$$

$$a_t = r\alpha \tag{10.11}$$



The **centripetal acceleration** is directed toward the center of rotation.

$$a_c = \frac{v^2}{r} = r\omega^2 \tag{10.12}$$

The **total linear acceleration** has both radial and tangential components and a magnitude given by Equation 10.13. *The magnitude of a_r equals a_c in Equation 10.12.*

$$a = \sqrt{a_t^2 + a_r^2} = r\sqrt{\alpha^2 + \omega^4} \tag{10.13}$$

1 One revolution per minute is about:
A. $0.0524 rad/s$ B. $0.105 rad/s$ C. $0.95 rad/s$ D. $1.57 rad/s$ E. $6.28 rad/s$

2. The angular speed of the second hand of a watch is:
A. $(\pi/1800) rad/s$ B. $(\pi/60) rad/s$ C. $(\pi/30) rad/s$ D. $(2\pi) rad/s$ E. $(60) rad/s$

3. The angular velocity of a rotating wheel increases by $2\,rev/s$ every minute. The angular acceleration in rad/s^2 of this wheel is:
A. $4\pi^2$ B. 2π C. $1/30$ D. $\pi/15$ E. 4π

4 When the initial angular velocity is $2\,rad/s$ the angular acceleration is $3\,rad/s^2$ and the time of motion is $4\,s$. What is the average angular velocity?
(A) $14\,rad/s$ (B) $16\,rad/s$ (C) $6\,rad/s$ (D) $8\,rad/s$

5. A wheel starts from rest and has an angular acceleration of $4.0\,rad/s^2$. The time it takes to make $10\,rev$ is:
(A) $31.416\,s$ (B) $15.708\,s$ (C) $5.605\,s$ (D) $3.963\,s$

6. A wheel rotates with a constant angular acceleration of $\pi\ rad/s^2$. During a certain time interval its angular displacement is $\pi\ rad$. At the end of the interval its angular velocity is $2\pi\ rad/s$. (a) What is its angular velocity at the beginning? (b) How long it takes to have the final angular velocity?
7. A certain wheel has a rotational inertia of $12\, kgm^2$. As it turns through 5.0 rev its angular velocity increases from $5.0\, rad/s$ to $6.0\, rad/s$. (a) What is the net torque of the system? (b) What work does it?
8. A wheel initially has an angular velocity of $18\, rad/s$. It has a constant angular acceleration of $2 rad/s^2$ and is slowing at first. What time elapses before its angular velocity is $18\, rad/s$ in the direction opposite to its initial angular velocity?
   A. 3 s B. 6 s C. 9 s D. 18 s E. 36 s
9. A particle moves in a circular path of radius $0.10\, m$ with a constant angular speed of $5\, rev/s$. The acceleration of the particle is:
   A. $0.10\pi m/s^2$ B. $0.50 m/s^2$ C. $500\pi m/s^2$ D. $1000\pi^2 m/s^2$ E. $10\pi^2 m/s^2$

10. A wheel rotates with a constant angular acceleration of $3.50 rad/s^2$. (a) If the angular speed of the wheel is $2\,rad/s$ at $t = 0$, through what angular displacement does the wheel rotate in $2\,s$? (b) Through how many revolutions has the wheel turned during this time interval? (c) What is the angular speed of the wheel at $t = 2\,s$?
11. A wheel starts from rest and rotates with constant angular acceleration to reach an angular speed of $12\,rad/s$ in $3\,s$. Find (a) the magnitude of the angular acceleration of the wheel and (b) the angle in radians through which it rotates in this time interval.
12. A centrifuge in a medical laboratory rotates at an angular speed of $3600\,rev/min$. When switched off, it rotates through 50 revolutions before coming to rest. Find the constant angular acceleration of the centrifuge.

13. The angular position of a swinging door is described by $\theta = 5 + 10t + 2t^2$, what is the angular speed and acceleration of the door at $t = 3\,sec$
14. A while initially at rest is rotated with constant angular acceleration of $100\,rad/s$ in $20\,sec$. If the radius of wheel is $0.3\,m$. What is the tangential acceleration of a point at the rim of the wheel?
15. A disc initially at rest rotates with constant angular acceleration through an angle of $22.5\,rad$ in $3\,sec$. What is the angular speed of the disk after $4\,sec$?
16. A wheel starts from rest and rotates with constant angular acceleration to reach an angular speed of $12\,rad/s$ in $3\,sec$. What is the magnitude of the angular acceleration of the wheel in rad/s^2 and the angle in rad through which it rotates in this time interval respectively?

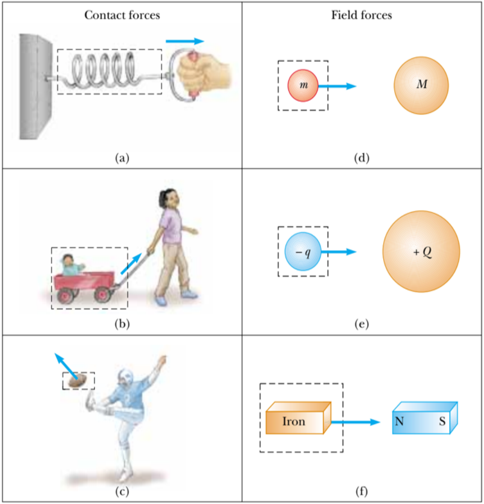
17. If an object of radius $3\,m$ that experiences a constant angular acceleration starting from rest, rotates $10\,rads$ in $2\,s$, what is its angular acceleration?

18. How long does it take for a rotating object to speed up from $15.0\,rad/s$ to $33.3\,rad/s$ if it has a uniform angular acceleration of $3.45\,rad/s^2$?

19. A pulley has an initial angular speed of $12.5\,rad/s$ and a constant angular acceleration of $3.41\,rad/s^2$. Through what angle does the pulley turn in $5.26\,s$?

20. During a certain period of time, the angular position of a swinging door is described by $\theta(t) = 5 + 10t + 2t^2$, where θ is in radians and t is in seconds. Determine the angular position, angular speed, and angular acceleration of the door (a) at $t = 0$ and (b) at $t = 3s$.

A force is an external agent capable of changing a body's state of rest or motion. There are two types of forces: 1. contact force, 2. non contact,



The only known fundamental forces in nature are all field forces:

1) gravitational forces between objects,
2) electromagnetic forces between electric charges,
3) nuclear forces between subatomic particles, and
4) weak forces that arise in certain radioactive decay processes.

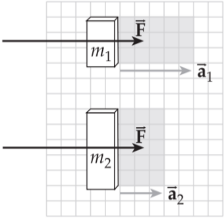
Units of Mass, Acceleration, and Force[a]

System of Units	Mass	Acceleration	Force
SI	kg	m/s^2	$N = kg \cdot m/s^2$
U.S. customary	slug	ft/s^2	$lb = slug \cdot ft/s^2$

- **Frames of Reference**
- When we say that something is moving, what we mean is that its position relative to something else is changing.
- For example, a passenger moves relative to an airplane; the airplane moves relative to the earth; the earth moves relative to the sun; the sun moves relative to the galaxy of stars (the Milky Way) of which it is a member; and so on.
- In each case a frame of reference is part of the description of the motion.
- To say that something is moving always implies a specific frame of reference.
- **Inertial frame of reference**
- In such a frame, an object at rest remains at rest and an object in motion continues to move at constant velocity (constant speed and direction) if no force acts on it.
- Any frame of reference that moves at constant velocity relative to an inertial frame is itself an inertial frame.

- Newton's first law of motion states
  In the absence of external forces, when viewed from an inertial reference frame, an object at rest remains at rest and an object in motion continues in motion with a constant velocity (that is, with a constant speed in a straight line).
- The tendency of an object to resist any attempt to change its velocity is called inertia.
- Mass: A **quantitative measurement of mass** (the term used to measure inertia) can be made by comparing the accelerations that a given force will produce on different bodies. If a given force acting on a body of mass m_1 produces an acceleration $\vec{\mathbf{a}}_1$ and the same force acting on a body of mass m_2 produces an acceleration $\vec{\mathbf{a}}_2$, the ratio of the two masses is defined as the inverse ratio of the magnitudes of the accelerations. *Mass is an inherent property of an object and is independent of the surroundings and the method of measurement.*

$$\frac{m_1}{m_2} \equiv \frac{a_2}{a_1}$$



- **Newton's second law is stated as:** When viewed from an inertial reference frame, the acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass.
- Mathematical statement of Newton's second law: $\sum \mathbf{F} = m\mathbf{a}$

$\sum F_x = ma_x \quad \sum F_y = ma_y \quad \sum F_z = ma_z$ It means, the net force (or resultant force) is the vector sum of all the external forces acting on the object.

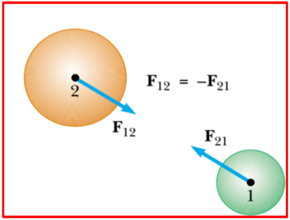
- This vector expression is equivalent to three component equations:

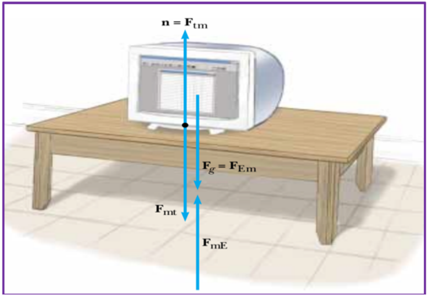
The **magnitude of the gravitational force** exerted on an object is called the weight of the object. *Weight is not an inherent property of a body; it depends on the local value of g and varies with location.*

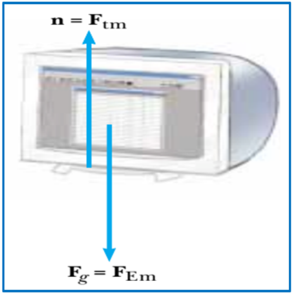
$F_g = mg$

weight $= mg$

Newton's third law states that the action force, $\vec{F}_{12}$, exerted by object 1 on object 2 is equal in magnitude and opposite in direction to the reaction force, $\vec{F}_{21}$, exerted by object 2 on object 1. *Remember, the two forces in an action–reaction pair always act on two different objects—they cannot add to give a net force of zero.*

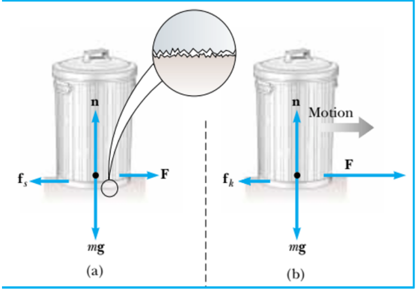


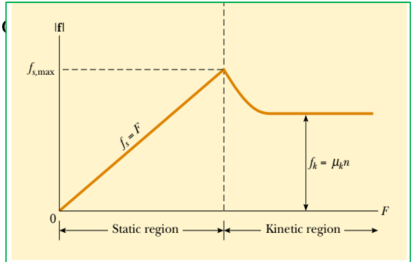




Forces of Friction

- When an object is in motion either on a surface or in a viscous medium such as air or water, there is **resistance to the motion** because the object interacts with its surroundings.
- We call such resistance a **force of friction**.
- the friction force arises from the nature of the two surfaces: because of their roughness.





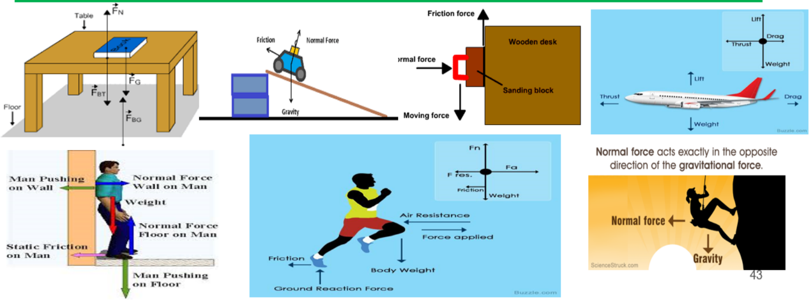
(c)

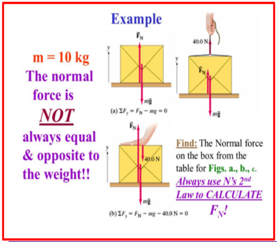
Normal Force

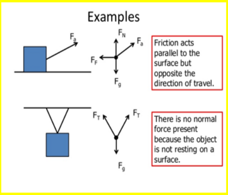
An object in equilibrium (modeled as a particle in equilibrium) has zero acceleration; the net force acting on the object is zero.

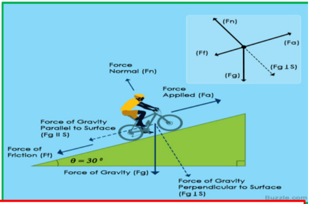
$$\boxed{\sum \vec{F} = 0} \longrightarrow \boxed{\sum \vec{F}_x = 0,\ \sum \vec{F}_y = 0 \ \&\ \sum \vec{F}_z = 0}$$

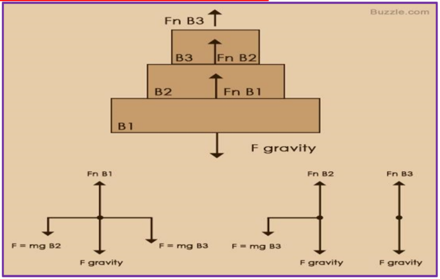
When a body presses against a surface, the surface (even a seemingly rigidone) deforms and pushes on the body with a normal force F_N that is perpendicular to the surface.











3. A 1.20 kg book is pushed against a vertical wall by a horizontal applied force. The coefficient of static friction between the book and the wall is 0.425. What is the amount of applied force needed to hold the book up without sliding?

The forces balance in each direction:

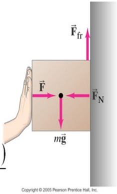
$$F_o = n \qquad F_{fr} = mg$$

Use the definition of friction to combine the two equations:

$$mg = F_{fr} \le \mu_s n = \mu_s F_o$$

$$\therefore F_o \ge \frac{mg}{\mu_s} = \frac{(1.20\,kg)(9.80\,m/s^2)}{(0.425)}$$

$$\boxed{F_o \ge 27.7\,N}$$

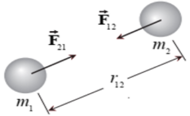


Newton's law of gravitation

Newton's law of universal gravitation states that every particle in the Universe attracts every other particle with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. *This is one example of a force form referred to as an inverse square law.*

$$F_g = G\frac{m_1 m_2}{r^2}$$

$$\vec{\mathbf{F}}_{12} = -G\frac{m_1 m_2}{r^2}\hat{\mathbf{r}}_{12}$$



$$\vec{\mathbf{F}}_{12} = -\vec{\mathbf{F}}_{21} \text{ (an action-reaction pair)}$$

The **universal gravitational constant** is designated by the symbol G.

$$G = 6.673 \times 10^{-11}\ \mathrm{N \cdot m^2/kg^2}$$

The **acceleration due to gravity** decreases with increasing altitude. In Equation 13.6, $r = (R_E + h)$ where h is measured from the Earth's surface. *At the surface of the Earth, $h = 0$ and as $r \to \infty$, the weight of an object approaches zero.*

$$g = \frac{GM_E}{r^2} = \frac{GM_E}{(R_E + h)^2}$$

Momentum

The **linear momentum** $\vec{\mathbf{p}}$ of a particle is defined as the product of its mass m and its velocity $\vec{\mathbf{v}}$. *This vector equation is equivalent to three component scalar equations, one along each of the coordinate axes.*

$$\vec{\mathbf{p}} \equiv m\vec{\mathbf{v}}$$

$$p_x = mv_x \qquad p_y = mv_y \qquad p_z = mv_z$$

The **net force acting on a particle** is equal to the time rate of change of the linear momentum of the particle. *This is a more general form of Newton's second law.*

$$\sum \vec{\mathbf{F}} = \frac{d\vec{\mathbf{p}}}{dt}$$

Impulse is a vector quantity, defined by Equation 9.9. The magnitude of an impulse caused by a force is equal to the area under the force-time curve.

$$\vec{\mathbf{I}} \equiv \int_{t_i}^{t_f} \sum \vec{\mathbf{F}}\, dt \qquad (9.9)$$

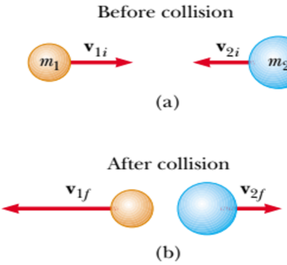
The **impulse-momentum theorem**, Equation 9.8, states that the impulse of a force $\vec{\mathbf{F}}$ acting on a particle equals the change in the momentum of the particle.

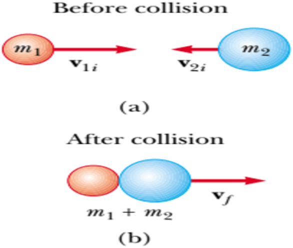
$$\Delta\vec{\mathbf{p}} = \vec{\mathbf{p}}_f - \vec{\mathbf{p}}_i = \int_{t_i}^{t_f} \sum \vec{\mathbf{F}}\, dt \qquad (9.8)$$

$$\Delta\vec{\mathbf{p}} = \vec{\mathbf{I}} \qquad (9.10)$$

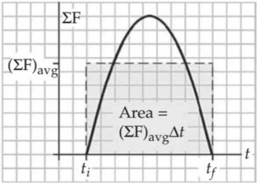
The **law of conservation of linear momentum states**: The total momentum of an isolated system (no external forces acting on the system) remains constant. There may be *internal forces* acting between particles within the system and the momentum of an *individual particle* may not be conserved. Although Equation 9.5 is written for a pair of particles, the conservation law holds for a system of any number of particles. *This fundamental law is especially useful in treating problems involving collisions between two bodies.*

$$\vec{\mathbf{p}}_{1i} + \vec{\mathbf{p}}_{2i} = \vec{\mathbf{p}}_{1f} + \vec{\mathbf{p}}_{2f} \quad (\text{when } \sum \vec{\mathbf{F}} = 0) \quad (9.5)$$





The **time-averaged force** $\left(\sum \vec{\mathbf{F}}\right)_{avg}$ is defined as that constant force which would give the same impulse to a particle as an actual time-varying force over the same time interval Δt. See the area outlined by the dashed line in the figure. *The impulse approximation assumes that one of the forces acting on a particle acts for a short time and is much larger than any other force present.* This approximation is usually made in collision problems, where the force is the contact force between the particles during the collision.



$$\vec{\mathbf{I}} = \sum \vec{\mathbf{F}}\,\Delta t \tag{9.13}$$

An **elastic collision** is one in which both linear momentum and kinetic energy are conserved.

$$\left.\begin{aligned} \vec{\mathbf{p}}_1 + \vec{\mathbf{p}}_2 &= \text{const.} \\ K_1 + K_2 &= \text{const.} \end{aligned}\right\} \text{(Elastic collision)}$$

An **inelastic collision** is one in which only linear momentum is conserved. *A perfectly inelastic collision is an inelastic collision in which the two bodies stick together after the collision.*

$$\vec{\mathbf{p}}_1 + \vec{\mathbf{p}}_2 = \text{const.} \quad \text{(Inelastic collision)}$$

The **common velocity following a perfectly inelastic collision** between two bodies can be calculated in terms of the two mass values and the two initial velocities. *This result is a consequence of conservation of linear momentum.*

$$\vec{\mathbf{v}}_f = \frac{m_1\vec{\mathbf{v}}_{1i} + m_2\vec{\mathbf{v}}_{2i}}{m_1 + m_2} \quad (9.15)$$

In an **elastic collision**, both momentum and kinetic energy are conserved. *Equations 9.16 and 9.17 apply in the case of a one-dimensional ("head-on") collision.*

$$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f} \quad (9.16)$$

$$\tfrac{1}{2} m_1 v_{1i}^2 + \tfrac{1}{2} m_2 v_{2i}^2 = \tfrac{1}{2} m_1 v_{1f}^2 + \tfrac{1}{2} m_2 v_{2f}^2 \quad (9.17)$$

The **relative velocity** before a perfectly elastic collision between two bodies equals the negative of the relative velocity of the two bodies following the collision. Equation 9.20 can be combined with Equation 9.16 to solve problems involving one-dimensional perfectly elastic collisions.

$$v_{1i} - v_{2i} = -(v_{1f} - v_{2f})$$

Example 1: A man is pulling a string, which is attached to a box. The string is at angle of 40° to the horizontal. The force applied to the box is 50 N. What is the force needed to move the box?

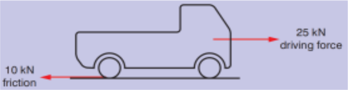


Figure 1: A lorry is traveling to the right

Example 1: Look at Figure 1, the mass of the lorry is 10 tonnes.
What will happen to lorry? It is good to think about the horizontal and vertical forces, i.e., positive horizontal force for the right direction and positive vertical force for the upward direction.

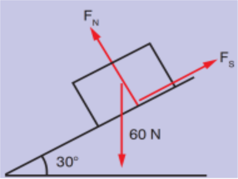


Figure 2: An inclined plane of a box

Example 2: A box that weighs 60 N is on a ramp, which is inclined at 30° to the horizontal as shown in Figure 2. The box is in limiting equilibrium.
Find the coefficient of friction between the box and the plane?

Example 2: A box is pulled along a flat table is 7 N. The mass of the box is 2 kg. Work out the coefficient of kinetic friction?

Example 2: Two roads are perpendicular and meet at a junction car A of mass 100 kg travels along one road at 20 m/s due North. Car B of mass 1300 kg, travels due West along the other road at 16 m/s.
a) Write down the initial velocities of the cars before collision in vector form?
b) Find the velocities after collision?

Example: A ball of mass 500 g and velocity $\begin{bmatrix} 5 \\ 2 \end{bmatrix}$ m/s bounces off a vertical wall.

a) what is the impulse of the ball? b) the ball changes direction in 0.1 s. What is the force exactly by the wall of the ball?

Example for elastic collision: The cur ball in a pool game is traveling at $\begin{bmatrix} 3 \\ -2 \end{bmatrix}$ m/s. It collides with a ball which is stationary. After the collision, the pool ball moves with a velocity of $\begin{bmatrix} 2 \\ 0.5 \end{bmatrix}$ m/s. What is the velocity of the cue ball after the collision?

Figure 7: 2-D elastic collision

Example for inelastic collision: Car A collides with car B, which is stationary and then both cars move together. Before the collision, car A had a velocity 5 m/s. The masses of car A and car B are 1250 kg and 1500 kg, respectively. What is the speed of the two cars after the collision?

Example 1: Figure 9 shows a rod with two masses attached to it. The distance from P are clearly shown in the diagram. The rod is mass less. The moment of two two masses can be balanced by a single force F acting at a distance x from the left hand end of the rod. Calculate x?

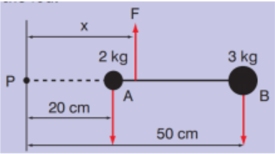


Figure 9: Center of mass

Example 2: A race track has a bend that is banked at angle of 10° and has a radius of 200 m. A racing car has a mass of 750 kg and the coefficient of static friction between the tyres and the rod surface is 0.6. What is the fastest speed the racing car can go round this bend?

1) A ball of mass 0.5 kg is held on a slope of 20° to the horizontal. The ball is let to go. What will the acceleration of the ball be?

2) A 20.0 kg object that can move freely is subjected to a resultant force of 45.0 N in the -x–direction. Find the acceleration of the object?

3)**ESSLCE** A force of unknown magnitude acts on a 2kg mass and gives 3 m/s^2. What acceleration will this force give to a 1kg mass? How large is the force?

4)**ESSLCE** The ration of the weight of a man in a stationary lift and in a lift accelerating downwards with a uniform acceleration, a is 3:2. The acceleration of the lift is?

A. g/3 B. g/2 C. g D. 2g

5)**ESSLCE** A block is kept on a frictionless inclined surface with angle of inclination α. The incline is given an acceleration, a, to keep the block stationary. Then the acceleration, a, is equal to:

A. $g \tan\alpha$ B. g C. $g \sec\alpha$ D. $g/\tan\alpha$

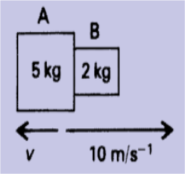


Figure 1: Recoil force

6) Consider a large mass and a small mass which are pushing one another apart, as shown in Figure 1. The small mass moves away at a velocity of 10 m/s to the right. What is the recoil velocity of the large mass?

7)**ESSLCE** Suppose that $F_1 = 5i - 3j + 2k$ and $F_2 = 7i + 24j - 14k$ are applied on a body of mass 3kg. What is the magnitude of the acceleration produced?

8) A rocket with a lift-off mass $10^5 kg$ is blasted upward with an initial acceleration of $5m/s^2$. The initial thrust of the blast is:

A. $1.5 \times 10^2 N$ B. $1.5 \times 10^3 N$ C. $1.5 \times 10^5 N$ D. $1.5 \times 10^6 N$

9)**ESSLCE** In a rocket, fuel is ejected with a velocity of $6km/s$. If the fuel burns at a rate of 1kg/s, then the force exerted by the exhaust gas on the rocket is:

A. $6000N$ B. $600N$ C. $60N$ D. $6N$

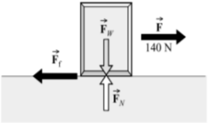


Figure 2: Example of force

10. A horizontal force of $140N$ is needed to pull a $60kg$ box across the horizontal floor at constant speed. What is the coefficient of friction between the floor and box? Determine it to three significant figures even though that is quiet unrealistic.

11) The momentum of the system is conserved: A. Always B. Never C. Only in the absence of external forces D. Only when an external force acts

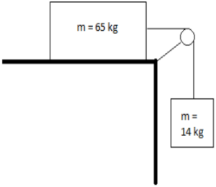


Figure 3: Tension of force

12) What is the acceleration of the system shown above?
(frictionless and the mass of the rope is negligible).
A. $2.2\frac{m}{s^2}$ B. $7.2\frac{m}{s^2}$ C. $14.0\frac{m}{s^2}$ D. $10\frac{m}{s^2}$ E. $1.8\frac{m}{s^2}$

13) A $100g$ mass is suspended by a string, which is passed over a wheel and attached to a $200g$ mass suspended on the opposite side of the pulley. If the blocks are released, what is the acceleration of the system?
14)**ESSLCE** What is the centripetal acceleration of the Earth as it moves in its own orbit around the sun?
15)**ESSLCE** A particle of mass $m_1 = 1.2kg$, $m_2 = 2.5kg$ and $m_3 = 3.4kg$ are located at the corners of an equilibrum triangle of sides $s = 140cm$. Where is the center of mass?
16) Mr. Alemu, $60kg$, is running at an initial speed of $4m/s$ jumps on to 120 kg cart that is initially at rest. Find the velocity of Mr. Alemu and the cart after impact?
17)**ESSLCE** Swimming is possible on account of
A. Newton 1^{st} Law B. Newton 2^{nd} Law C. Newton 3^{rd} Law D. Newton Law of Gravitation
18). A bullet of $15g$ is fired horizontally into a $3kg$ block of wood suspended by a cord. The bullet sticks in the block and it is swing $10cm$ above its initial level. Compute the initial speed of the bullet?
19)**ESSLCE** A block of mass $8kg$ is pushed up against a well by a force F that makes a $40°$ with the horizontal. Assuming $\mu_s = 0.3$. What possible value of$F$ will hold the block in position?
20)**ESSLCE**. If the Earth shrinks, what will be the effect on the value of acceleration due to gravity g?
A. It will decrease B. It will increase C. It will become zero D. It will become infinite
21). Mars has a mass of $6.46 \times 10^{23}kg$ and a radius of 3.39×10^6m. What is the acceleration due to gravity of Mars?