İstanbul Bilgi University

Course Khana

كورس خانة

Mid-Term Revision Physics1

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Horizon

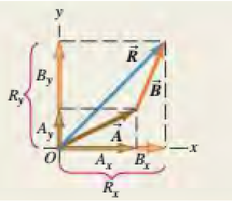
هو ريزن

Vectors

- **Scalars Vs. Vectors:**
  - Scalar quantities are numbers and combine according to the usual rules of arithmetic.
  - Vector quantities have direction as well as magnitude and combine according to the rules of vector addition.

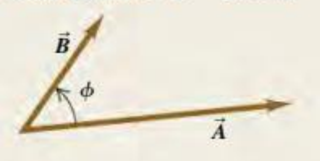
- **Vector addition:**
  - The negative of a vector has the same magnitude but points in the opposite direction.
  - Vectors can be added by using components of vectors.
    $\vec{R} = \vec{A} + \vec{B}$

$$R_x = A_x + B_x$$
$$R_y = A_y + B_y$$
$$R_z = A_z + B_z$$



  - Unit vectors describe directions in space. Unit vector has a magnitude of 1. $\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k}$

- **Scalar product & Vector product:**
  - $\vec{A}.\vec{B} = AB\cos\theta = |\vec{A}||\vec{B}|\cos\theta$
  - $\vec{A}.\vec{B} = A_xB_x + A_yB_y + A_zB_z$



Scalar product $\vec{A}\cdot\vec{B} = AB\cos\phi$

$\vec{A} = 5\hat{i} + 4\hat{j} - 2\hat{k}$

$\vec{B} = 2\hat{i} - 3\hat{j} + 7\hat{k}$

① Find $2\vec{A} + \vec{B}$

② Find $\vec{A} \cdot \vec{B}$

① $2\vec{A} + \vec{B} = 2(5\hat{i} + 4\hat{j} - 2\hat{k}) + (2\hat{i} - 3\hat{j} + 7\hat{k})$

$= (10\hat{i} + 8\hat{j} - 4\hat{k}) + (2\hat{i} - 3\hat{j} + 7\hat{k})$

$= 12\hat{i} + 5\hat{j} + 3\hat{k}$

② $\vec{A} \cdot \vec{B} = 10 + (-12) + (-14)$

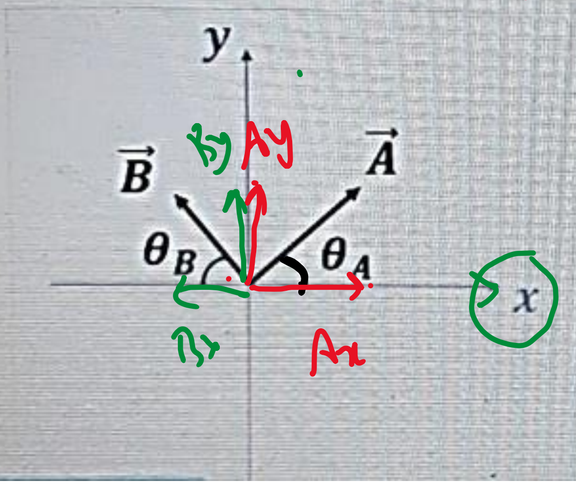
$= -16$

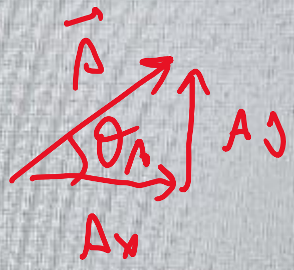
Question 1:

Consider the two vectors shown below. The two vectors have magnitudes of $|\vec{A}| = 29$ and $|\vec{B}| = 20$. The small angles the two vectors make with the x-axis are $\theta_A = 30^o$ and $\theta_B = 44^o$. Determine the magnitude of the vector $|\vec{C}|$ given by:

$$\vec{C} = 4\vec{A} - 1\vec{B}$$

Please express your answer using zero decimal place.





$A_x = A\cos\theta_A = 29 \times \cos 30^\circ = 25.11$

$A_y = A\sin\theta_A = 29 \times \sin 30^\circ = 14.5$

$$\boxed{\vec{A} = 25.11\,\hat{i} + 14.5\,\hat{j}}$$

$B_x = -B\cos\theta_B = -20 \times \cos 44^\circ = -14.39$

$B_y = +B\sin\theta_B = +20 \times \sin 44^\circ = 13.89$

$$\boxed{\vec{B} = -14.39\,\hat{i} + 13.89\,\hat{j}}$$

$\vec{C} = 4(25.11\hat{i} + 14.5\hat{j}) - (-14.39\hat{i} + 13.89\hat{j})$

$= (100.44\hat{i} + 58\hat{j}) - (-14.39\hat{i} + 13.89\hat{j})$

$$\boxed{\vec{C} = 114.83\,\hat{i} + 44.11\,\hat{j}}$$

$$|\vec{C}| = \sqrt{C_x^2 + C_y^2}$$

$$= \sqrt{(114.83)^2 + (44.11)^2}$$

$$\boxed{|\vec{C}| = 123}$$

Kinematics

$$\boxed{\vec{r} = x\hat{\imath} + y\hat{\jmath} + z\hat{k}}$$

$$\vec{v}_{av} = \frac{\vec{r}_2 - \vec{r}_1}{t_2 - t_1} = \frac{\Delta\vec{r}}{\Delta t}$$

$$\vec{v} = \qquad a_x = \frac{dv_x}{dt} \qquad a_y = \frac{dv_y}{dt} \qquad a_z = \frac{dv_z}{dt}$$

$$v_x = \frac{dx}{dt} \qquad v_y = \frac{dy}{dt} \qquad v_z = \frac{dz}{dt}$$

$$\vec{a}_{av} = \frac{\vec{v}_2 - \vec{v}_1}{t_2 - t_1} = \frac{\Delta\vec{v}}{\Delta t}$$

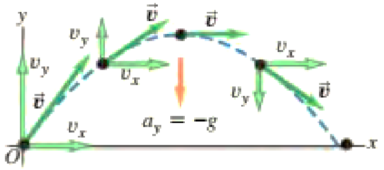
$$\vec{a} = \lim_{\Delta t \to 0} \frac{\Delta\vec{v}}{\Delta t} = \frac{d\vec{v}}{dt}$$

Constant x-acceleration only:

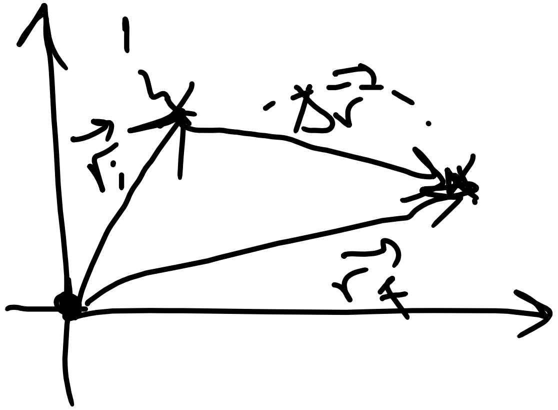
- $v_x = v_{0x} + a_x t$
- $x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2$
- $v_x^2 = v_{0x}^2 + 2a_x(x - x_0)$
- $x - x_0 = \frac{1}{2}(v_{0x} + v_x)t$

Projectile motion:

In projectile motion with no air resistance, $a_x = 0$ and $a_y = -g$. The coordinates and velocity components are simple functions of time, and the shape of the path is always a parabola. We usually choose the origin to be at the initial position of the projectile.



$$x = (v_0 \cos\alpha_0)t$$
$$y = (v_0 \sin\alpha_0)t - \frac{1}{2}gt^2$$
$$v_x = v_0 \cos\alpha_0$$
$$v_y = v_0 \sin\alpha_0 - gt$$



$$\vec{\Delta r} = \vec{r_f} - \vec{r_i}$$

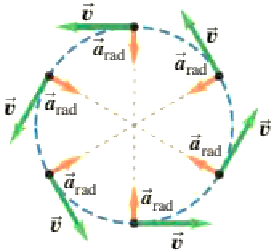
$$\vec{v} = \frac{d\vec{r}}{dt}$$

$$\vec{a} = \frac{d\vec{v}}{dt}$$

Uniform and nonuniform circular motion:

When a particle moves in a circular path of radius R with constant speed v (uniform circular motion), its acceleration $\vec{a}$ is directed toward the center of the circle and perpendicular to $\vec{v}$.

If the speed is not constant in circular motion (nonuniform circular motion), there is still a radial component of $\vec{a}$, but there is also a component of $\vec{a}$ parallel (tangential) to the path. This tangential component is equal to the rate of change of speed, dv/dt.



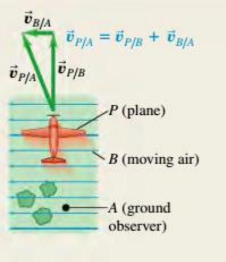
$$a_{tan} = \frac{d|\vec{v}|}{dt} \qquad \boxed{a_{rad} = \frac{v^2}{R}} \qquad v = \frac{2\pi R}{T} \qquad a_{rad} = \frac{4\pi^2 R}{T^2}$$

Relative velocity:

When a body P moves relative to a body (o reference frame) B, and B moves relative to a body (or reference frame) A.

$v_{P/A\text{-}x} = v_{P/B\text{-}x} + v_{B/A\text{-}x}$
(relative velocity along a line)

$\vec{v}_{P/A} = \vec{v}_{P/B} + \vec{v}_{B/A}$
(relative velocity in space)



Question 2:

A particle's position along the x-axis is given by the equation;

$$x(t) = 2t^4 + 2t^2 + 6$$

where x is in meters and t is in seconds. What is this particles average velocity between $t = 1s$ and $t = 3s$?

Please express your answer with **zero** decimal places in units of m/s.

② what is its instantaneous velocity at $t = 2s$?

③ what is its instantaneous acceleration at $t = 2s$?

① $v_{av} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i} =$

$x_f(t=3) = 2(3)^4 + 2(3)^2 + 6 = 186\ m$

$x_i(t=1) = 2(1)^4 + 2(1)^2 + 6 = 10\ m$

$v_{av} = \frac{186 - 10}{3 - 1} = 88\ m/s$

② $v = \frac{dx}{dt} = \frac{d}{dt}(2t^4 + 2t^2 + 6)$

$\boxed{v(t) = 8t^3 + 4t}$

$v(t=2) = 8(2)^3 + 4(2)$

$= 72\ m/s$

③ $a = \frac{dv}{dt} = \frac{d}{dt}(8t^3 + 4t)$

$a = 24t^2 + 4$

$a(t=2) = 24(2)^2 + 4$

$= 100\ m/s^2$

Question 3:

A particle is moving in three dimensions and its position vector is given by;

$$\vec{r}(t) = (1.2t^2 + 3.7t)\hat{i} + (3t - 2.1)\hat{j} + (2.4t^3 + 2t)\hat{k}$$

where r is in meters and t is in seconds.
Determine the **magnitude** of the instantaneous acceleration at $t = 2\text{s}$.
Express your answer in units of m/s^2 using one decimal place.

$$\vec{a} = \frac{d\vec{v}}{dt} \quad , \quad \vec{v} = \frac{d\vec{r}}{dt}$$

$$\vec{v} = (2.4t + 3.7)\hat{i} + (3)\hat{j} + (7.2t^2 + 2)\hat{k}$$

$$\vec{a} = (2.4)\hat{i} + (14.4t)\hat{k}$$

$$\vec{a}(t=2) = 2.4\hat{i} + 14.4(2)\hat{k}$$

$$\vec{a} = 2.4\hat{i} + 28.8\hat{k}$$

$$|\vec{a}| = \sqrt{(2.4)^2 + (0)^2 + (28.8)^2}$$

$$= 28.8998$$

$$\boxed{|\vec{a}| = 28.9 \text{ m/s}^2}$$

Question 4:

A stone is dropped off a cliff. After this stone has traveled a distance d, a second stone is dropped. Assuming no air resistance, until one of them hits the ground, the distance between the two stones will always:

Hide answer choices ^

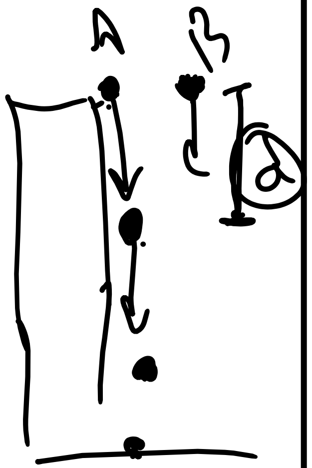
(A) decrease at first, but then stay constant.

(B) decrease.

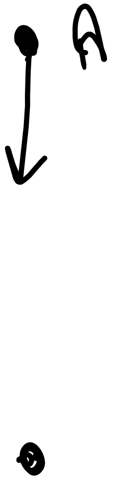
(C) increase at first, but then stay constant.

(D) Incorrect:
stay constant.

(E) increase. Correct answer



Free fall



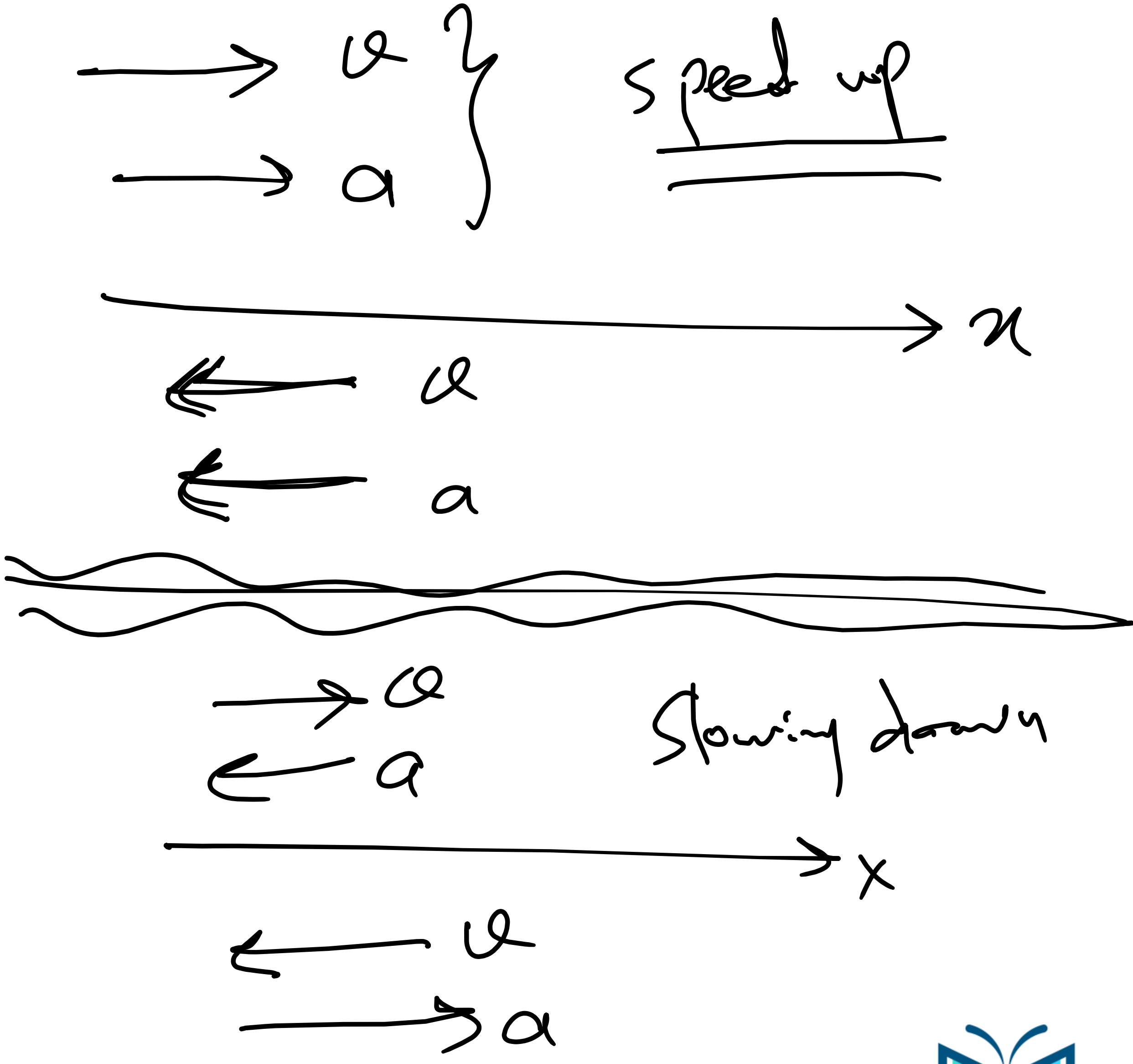
$\downarrow \vec{g} = 9.81\ m/s^2$

$$\boxed{y_A = y_{0A} + \cancel{v_{0A}} t - \frac{1}{2} g t^2}$$

Question 5:

If the initial velocity of an object moving in one dimension is positive and has a positive acceleration, it will speed up.

- **T** True — *Correct answer*
- **F** False



Question 6:

The slope of a line connecting two points on a velocity versus time graph gives:

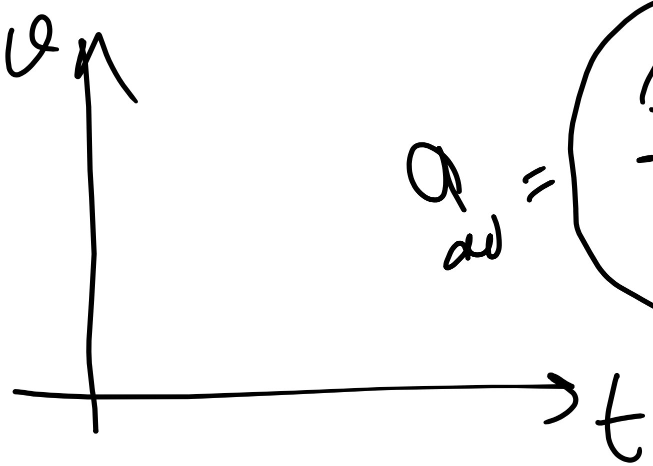
Hide answer choices

(A) Instantaneous velocity ✗

(B) average velocity ✗

(C) instantaneous acceleration ✗

(D) average acceleration — Correct answer

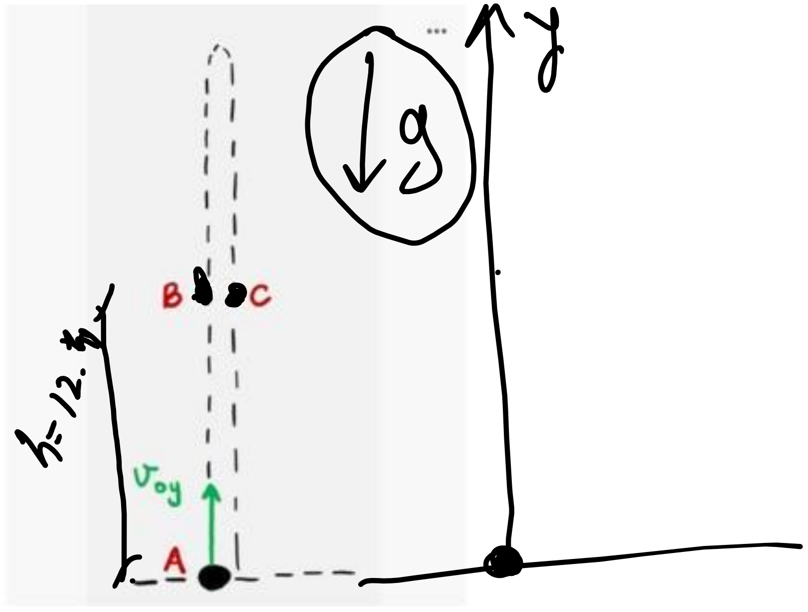


$$a_{av} = \frac{\Delta v}{\Delta t}$$ مجال

لحظي $$\boxed{a = \frac{dv}{dt}}$$

Question 7:

A rock is thrown directly up an with an initial velocity of $v_{oy} = 25.9$ m/s at instant **A** as shown in the figure below. As it moves up, it will reach a certain height $h = 12.4$m at insant **B**. It comes back to the same height during its fall from the maximum height at instant **C**. Determine the time it takes for the rock to go from **A** to **C**. Express your answer using one decimal place in units of seconds. *Take* $g = 9.81\ m/s^2$.



$v = v_i - gt$ / $y = y_i + v_i t - \frac{1}{2} g t^2$

$v^2 = v_0^2 - 2g\Delta y$

A → C :

$y_C = y_A + v_A t - \frac{1}{2} g t^2$

$12.4 = 0 + 25.9t - \frac{1}{2}(9.81)t^2$

$4.905t^2 - 25.9t + 12.4 = 0$

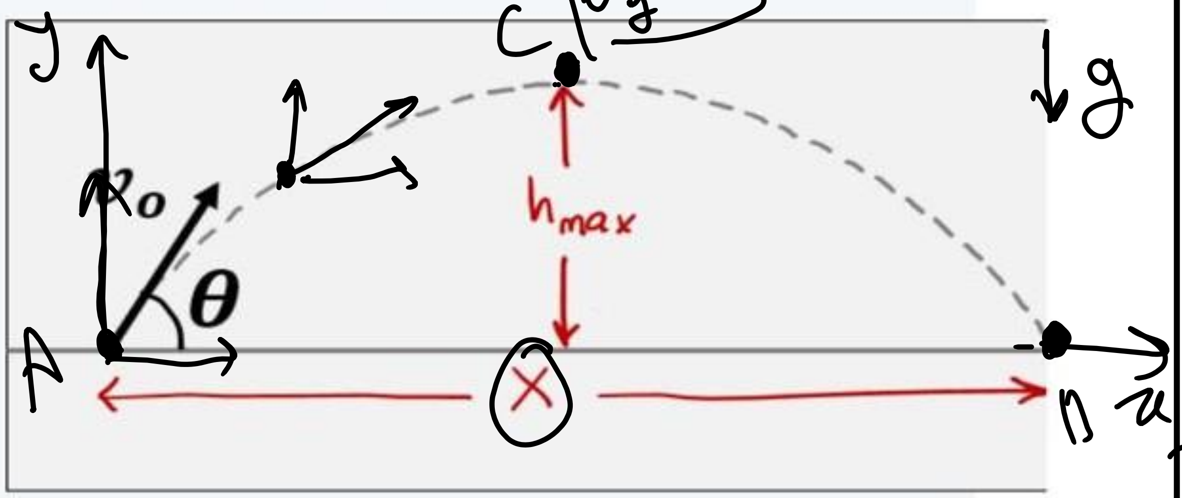
$\boxed{t_1 = 4.748 \text{ s} \downarrow}$

$t_2 = 0.532 \text{ s} \uparrow$

$\boxed{t_c = 4.7 \text{ s}}$

Question 8:

A projectile is launched from ground as shown in the figure below. If $h_{max} = 27\text{m}$ and the angle the launch velocity makes with the horizontal is $\theta = 37^o$, determine the horizontal range. Take $g = 9.81\text{m/s}^2$ and express your answer in units of meters with zero decimal places.



$v_{ix} = v_0 \cos\theta$ / $v_{iy} = v_0 \sin\theta$

x	y
$a_x = 0$	$a_y = -g$
$x = x_i + v_{ix} t + \cancel{\frac{1}{2} a_x t^2}$	$y = y_i + v_{iy} t - \frac{1}{2} g t^2$
$v_x = v_{ix} + \cancel{a_x t}$	$v_y = v_{iy} - g t$

At C: $v_y = v_{iy} - g t$

$$\boxed{0 = v_0 \sin\theta - g t}$$

$$y = y_i + v_{iy} t - \frac{1}{2} g t^2$$

$$\boxed{27 = 0 + v_0 \sin\theta \, t - \frac{1}{2} g t^2}$$

$$v^2 = v_0^2 - 2g \Delta y$$

or $v_y^2 = v_{iy}^2 - 2g\,\Delta y$

$0 = v_{iy}^2 - 2(9.81)(27)$

$v_{iy}^2 = 529.74$

$v_{iy} = 23.02$ m/s

$v_{iy} = v_0 \sin\theta$

$v_0 = \dfrac{v_{iy}}{\sin\theta} = \dfrac{23.02}{\sin 37^\circ}$

$\boxed{v_0 = 38.25 \text{ m/s}}$

$v_{0x} = v_0 \cos\theta$

$= 38.25 \times \cos 37$

$\boxed{v_{0x} = 30.55 \text{ m/s}} = v_x$

t_B: $A \to B$:

$y = y_i + v_{iy} t - \frac{1}{2} g t^2$

$0 = 0 + 23.02t - \frac{1}{2}(9.81)t^2$

$t(23.02 - 4.905t) = 0$

$23.02 - 4.905t = 0$

$t_B = 4.69$ s

$$X = x_i + v_{ix} t$$

$$= 0 + 30.55\,(4.69)$$

$$= 143.28$$

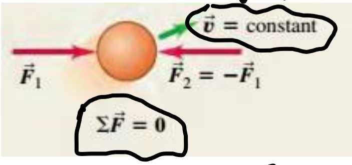
$$\boxed{X = 143 \text{ m}}$$

Newton's Laws of Motion

$\boxed{\vec{a}=0}$ at rest / motion with $\vec{v}$ = constant

Newton's first law:

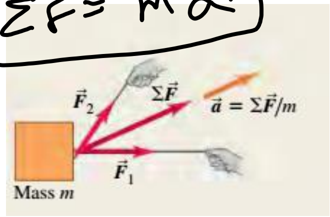
Newton's first law states that when the vector sum of all forces acting on a body (the *net force*) is zero, the body is in equilibrium and has zero acceleration. If the body is initially at rest, it remains at rest; if it is initially in motion, it continues to move with constant velocity.



Newton's second law:

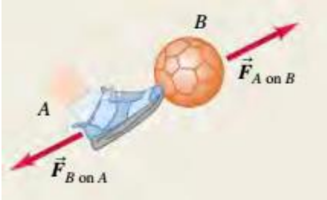
$\boxed{\Sigma\vec{F} = m\vec{a}}$

The inertial properties of a body are characterized by its *mass*. The acceleration of a body under the action of a given set of forces is directly proportional to the vector sum of the forces (the *net force*) and inversely proportional to the mass of the body. This relationship is Newton's second law.



Newton's third law and action–reaction pairs:

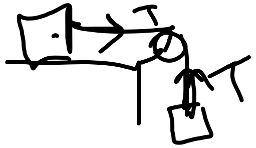
Newton's third law states that when two bodies interact, they exert forces on each other that are equal in magnitude and opposite in direction. These forces are called action and reaction forces. Each of these two forces acts on only one of the two bodies; they never act on the same body

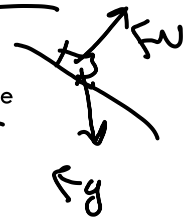


$$\vec{F}_{A\text{ on }B} = -\vec{F}_{B\text{ on }A}$$

F_{12} | F_{21}

Type of forces:





fN ⊥ surface

$F_g = mg$

w

1. Weight 2. Normal force 3. Applied force 4. Tension force 5. Friction force

Friction force:

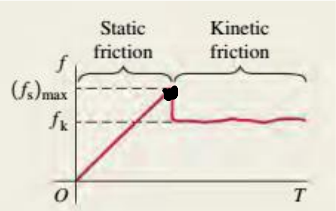
The contact force between two bodies can always be represented in terms of a normal force $\vec{n}$ perpendicular to the surface of contact and a friction force $\vec{f}$ parallel to the surface.

Magnitude of kinetic friction force:

$$\boxed{f_k = \mu_k n}$$

Magnitude of static friction force:

$$\boxed{f_s \leq (f_s)_{max} = \mu_s n}$$

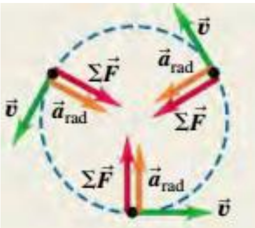


Forces in circular motion:

In uniform circular motion, the acceleration vector is directed toward the center of the circle.

Acceleration in uniform circular motion:

$$a_{rad} = \frac{v^2}{R} = \frac{4\pi^2 R}{T^2} \qquad (5.13), (5.15)$$



$F_s = 5$ N

$F = 5$ N

$F = 10$ N

$f_s = 10$ N

$$\boxed{\Sigma F = m a_{rad}}$$

Question 9:

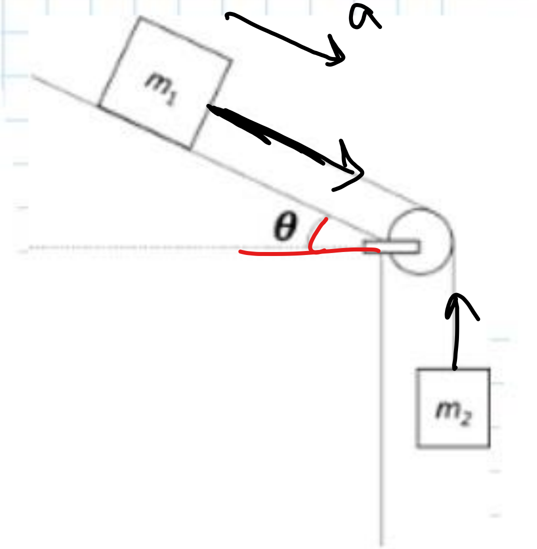
Two blocks ($m_1 = m_2 = 5$ kg) are connected by a string that passes through a massless pulley as shown in the Figure. The first block with mass m_1 slides on an inclined plane when the system is released. The inclined plane makes an angle $\theta = 37^o$ with the horizontal and the kinetic friction coefficient between the inclined plane and m_1 is $\mu_k = 0.5$.

a) Draw the free body diagram for each block.

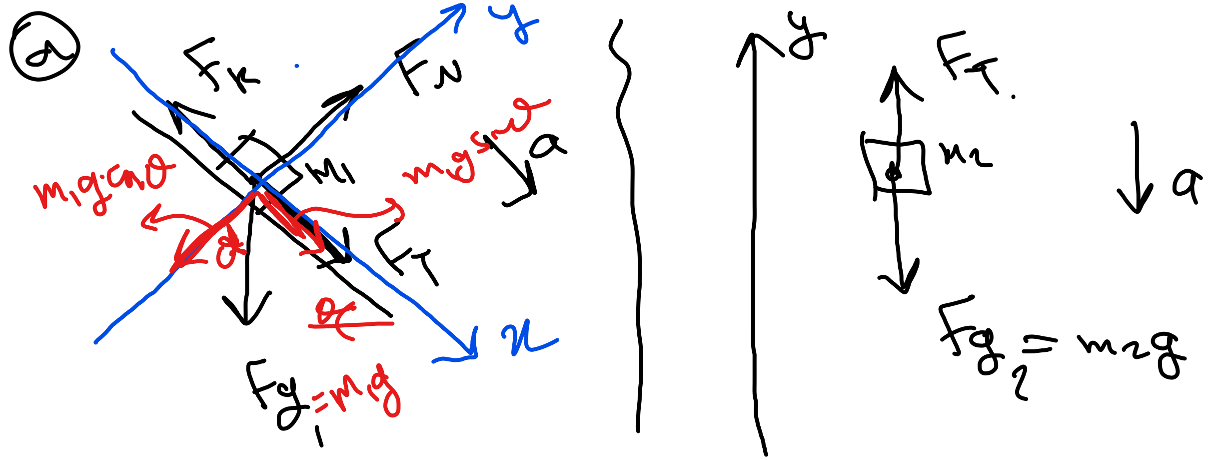
b) Determine the acceleration of the blocks.

c) Determine the tension on the string.

$\boxed{g = 10 \ m/s^2}$



(a)



m_2: $\Sigma \vec{F} = m_2 \vec{a} \Rightarrow \Sigma F_y = m_2 a_y$

$F_T - m_2 g = m_2(-a)$

$F_T - 5(10) = 5(-a)$

$\boxed{F_T - 50 = -5a}$ --- ①

m_1: $\Sigma F_x = m_1 a$

$F_T - F_k + m_1 g \sin\theta = m_1 a$

$F_k = \mu_k \cdot F_N$

$\Sigma F_y = \cancel{m_1 a_y}\ 0$

$F_N - m_1 g \cos\theta = 0 \Rightarrow F_N = m_1 g \cos\theta$

$F_K = \mu_K \cdot (m_1 g \cos\theta) = (0.5)(5)(10) \cos 37°$

$F_K = 19.97\ N$

$F_T - 19.97 + (5)(10) \sin 37 = 5a$

$\boxed{F_T + 10.12 = 5a}$ . . ②

② − ① : $F_T + 10.12 - F_T + 50 = 5a + 5a$

$60.12 = 10a$

$a = 6.012\ m/s^2$

$\boxed{a = 6\ m/s^2}$

$F_T - 50 = -5(6.012)$

$F_T = 19.94$

$\boxed{F_T = 20\ N}$

Question 10:

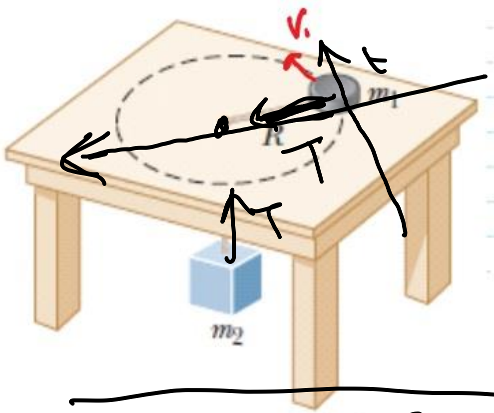
A puck of mass m_1 is tied to a string and allowed to revolve in a circle of radius R on a frictionless, horizontal table. The other end of the string passes through a small hole in the center of the table, and an object of mass m_2 is tied to it.

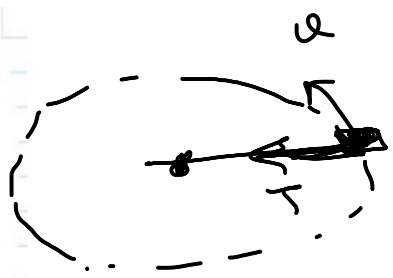
The suspended object remains in equilibrium while the puck on the tabletop revolves. Find expressions for

(a) the tension in the string,

(b) the radial force acting on the puck,

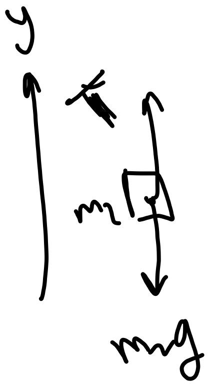
(c) the speed of the puck.





$$\boxed{a_{rad} = \frac{v^2}{R}}$$

$$\boxed{\sum \vec{F} = m\vec{a}}$$



$$\sum F = \cancel{m_2 a}^{\,0}$$

$$T - m_2 g = 0$$

$$\boxed{T = m_2 g}$$

$$\sum F_R = m_1 a_{rad}$$

$$\boxed{\sum F_R = m_1 \frac{v^2}{R}}$$

$$\sum F_R = T$$

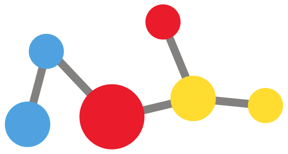
$$m_2 g = m_1 \frac{v^2}{R}$$

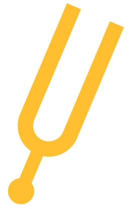
$$v^2 = \frac{m_2 g R}{m_1}$$

$$\boxed{v = \sqrt{\frac{m_2}{m_1} g R}}$$

ANY

QUESTION





THANK YOU