

Ministry Of Education

وزارة التربية والتعليم

Department of Education And Knowledge

دائرة التعليم والمعرفة

Al- Qudra school

مدرسة القدرة

# مفاتيح المعرفة



**General revision in Physics**

**Grad :11-Advance**

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## الترميز العلمي scientific notation

يتم تمثيل العدد كحاصل ضرب

1  $\leq$  عدد ( mantissa )  $\geq 10$  مضروباً في 10 مرفوعة power ( أس )  $exponent$  = عدد منازل الأصفار )

$$\text{number} = \text{mantissa} \times 10^{\text{exponent}}$$

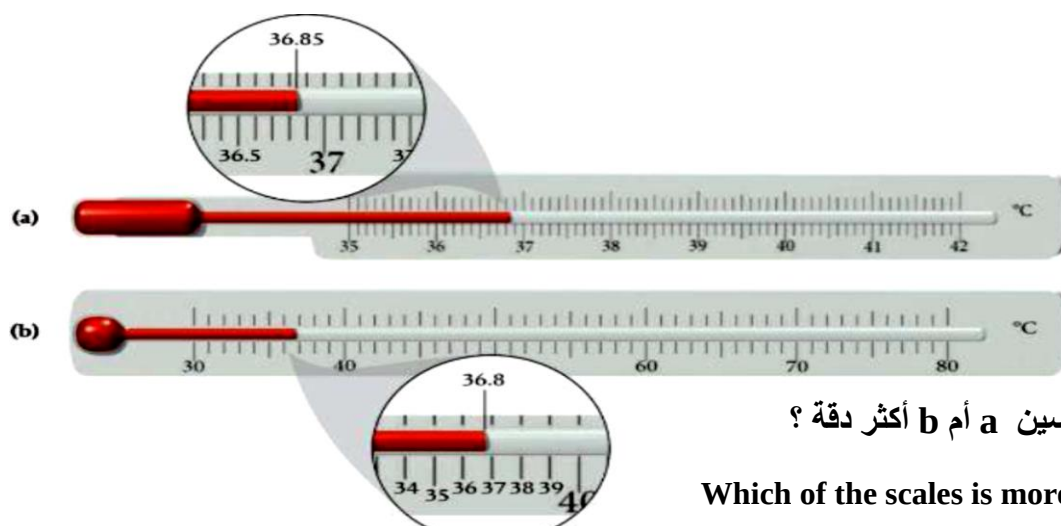
## الأرقام المعنوية significant figures

يحدد عدد الأرقام المعنوية significant figures

The number of digits in the mantissa

التي نكتبها في الجزء العشري مدي دقة ما تدعي معرفته ( تزيد الدقة بزيادة عدد الأرقام المحددة )

The number of digits you write in the mantissa specifies how precisely you claim to know it the more digits specified the more precision is implied



س/ أي المقياسين a أم b أكثر دقة ؟

Which of the scales is more precision?

- The number of significant figures is the number of reliably known digits  
العدد (  $9.11 \times 10^{-31}$  ) three significant figures
- Number in significant figures have as many significant figures as their mantissa  
ليساوي 0.357 3 significant figures حيث يتعين علينا تقريبه إلى 3 significant figures
- You can never have more significant figures in a result that you start with in any of the factors of multiplication or division

For example:  $1.23 \div 3.4461$  we must round a calculator result to the proper number of significant figures  
 $1.23 \div 3.4461 = 0.357$

- you can only add or subtract when there are significant figures for that place in every number

For example  $1.23 + 3.4461 = 4.68$  and not 4.6761

**O:** How many significant figures are in each of the following numbers?

- a) 4.01      c) 4      e) 0.00001      g)  $7.01 \times 3.1415$   
b) 4.010      d) 2.00001      f)  $2.1 - 1.10042$

**Q:** Calculate the following. Give the answer in correct scientific notation and significant figures.

- a)  $3.95 \times 10^2 / 1.5 \times 10^6$       b)  $(3.5 \times 10^2)(6.45 \times 10^{10})$   
c)  $4.44 \times 10^5 + 2.25 \times 10^5$       d)  $(4.50 \times 10^{-12}) - (3.67 \times 10^{-12})$   
e)  $1.05 \times 10^{-26} / 4.2 \times 10^{56}$       f)  $(2.5 \times 10^9)(6.45 \times 10^4)$   
g)  $6.022 \times 10^3 + 3.011 \times 10^3$       h)  $(6.88 \times 10^2) - (3.45 \times 10^{-10})$

### قواعد الترميز Notation Convention

It is common practice to use roman letters for unit abbreviations and italic letters for physical quantities

For example : ( m ) stands for the unit meter , while ( *m* ) is used for the physical quantity mass.

**O:** The masses of four sugar cubes are measured to be 25.3 g, 24.7 g, 26.0 g, and 25.8 g. Express the answers to the following questions in scientific notation, with standard SI units and an appropriate number of significant figures.

- a) If the four sugar cubes were crushed and all the sugar collected, what would be the total mass, in kilograms, of the sugar?  
b) What is the average mass, in kilograms, of these four sugar cubes?

•**1.47** What is the surface area of a right cylinder of height 20.5 cm and radius 11.9 cm?

## metrology

is the science of measurement. It establishes a common understanding of units, crucial in linking human activities.

### 1.5 General Problem-Solving Strategy

**General blueprint that should help get you started :**

- 1- THINK** Read the problem carefully . Ask yourself what quantities are known, what quantities might be useful but are unknown, and what quantities are asked for .
- 2- SKETCH** Make a sketch of the physical situation.
- 3- RESEARCH** Write down the physical principles or laws that apply to the problem.
- 4- SIMPLIFY** Do not plug numbers into your equation yet! Instead, simplify your result algebraically as much as possible.
- 5- CALCULATE** Put the numbers with units in the equation and get to work with a calculator.
- 6- ROUND** Determine the number of significant figures that you want to have in your result.
- 7- DOUBLE-CHECK** Step back and look at the result. Judge for yourself if the answer ( both the numbers and the units ) seems realistic.

### PROBLEM

The volume of a barrel of oil is 159 L. We need to design a cylindrical container that will hold this volume of oil. The container needs to have a height of 1.00 m to fit in a transportation container. What is the required circumference of the cylindrical container?

$$V = \pi r^2 h.$$

فما المحيط المطلوب للحاوية الأسطوانية ؟  
 $c = 2\pi r.$

$$c = 2\pi r \Rightarrow r = \frac{c}{2\pi}$$

$$V = \pi r^2 h = \pi \left( \frac{c}{2\pi} \right)^2 h = \frac{c^2 h}{4\pi}.$$

$$V = \frac{C^2 h}{4\pi} \quad \Rightarrow \quad C = \sqrt{\frac{4\pi V}{h}}$$

**Thus in SI units**

$$V = 159 \text{ L} \frac{1000 \text{ mL} \cdot 1 \text{ cm}^3 \cdot \text{m}^3}{\text{L} \cdot 1 \text{ mL} \cdot 10^6 \text{ cm}^3} = 0.159 \text{ m}^3$$

**Then**

$$C = \sqrt{\frac{4\pi(0.159 \text{ m}^3)}{1.00 \text{ m}}} = 1.41 \text{ m}$$

**PROBLEM**

Nuclear waste material in a physics laboratory is stored in a cylinder of height  $4\frac{13}{16}$  inches and circumference  $8\frac{3}{16}$  inches. What is the volume of this cylinder, measured in metric units?

$$1 \text{ in} = 2.54 \text{ cm}$$

$$h = 4\frac{13}{16} \text{ in} = 4.8125 \text{ in}$$

$$= (4.8125 \text{ in}) \cdot (2.54 \text{ cm/in})$$

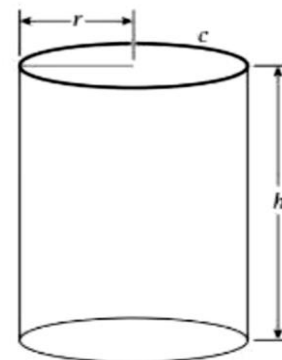
$$= 12.22375 \text{ cm.}$$

$$c = 8\frac{3}{16} \text{ in} = 8.1875 \text{ in}$$

$$= (8.1875 \text{ in}) \cdot (2.54 \text{ cm/in})$$

$$= 20.79625 \text{ cm.}$$

فما حجم هذه الأسطوانة مقيساً بالوحدات المترية ؟



and

$$V = \pi r^2 h.$$

$$c = 2\pi r.$$

$$c = 2\pi r \Rightarrow r = \frac{c}{2\pi}$$

$$V = \pi r^2 h = \pi \left( \frac{c}{2\pi} \right)^2 h = \frac{c^2 h}{4\pi}.$$

then

$$\begin{aligned} V &= \frac{c^2 h}{4\pi} \\ &= \frac{(20.8 \text{ cm})^2 \cdot (12.2 \text{ cm})}{4\pi} \\ &= 420.026447 \text{ cm}^3. \end{aligned}$$

**PROBLEM**

It goes without saying that one can see farther from a tower than from ground level; the higher the tower, the farther one can see. The Willis Tower in Chicago has an observation deck, which is 412 m above ground. How far can one see out over Lake Michigan from this observation deck under perfect weather conditions? (Assume eye level is at 413 m above the level of the lake.)

س: برج مراقبة ارتفاعه 412 m إلى أي مدى يمكن للشخص العادي الرؤية من منصة المراقبة أعلى البرج هذا في ظل الظروف المناخية المثالية ؟

$$R = 6.37 \times 10^6 \text{ m} \quad \text{نصف قطر الأرض}$$

$$r^2 = (R + h)^2 - R^2$$

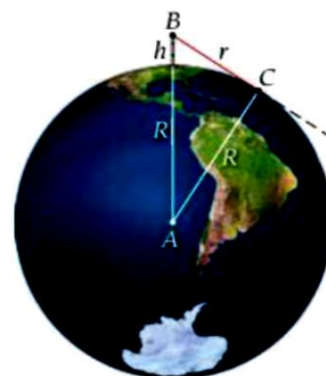
$$r^2 = R^2 + 2hR + h^2 - R^2$$

$$r = \sqrt{2hR + h^2}$$

$$r = \sqrt{2 \times 4.13 \times 10^2 \text{ m} \times 6.37 \times 10^6 \text{ m} + (4.12 \times 10^2 \text{ m})^2}$$

$$r = 7.25382 \times 10^4 \text{ m} = 7.25 \times 10^4 \text{ m}$$

$$r = 72.5 \text{ km}$$



**PROBLEM**

If the radius of a cylinder increases by a factor of 2.73, by what factor does the volume change? Assume that the height of the cylinder stays the same.

$$\frac{V_1}{V_2} = \left( \frac{r_1}{2.73r_1} \right)^2$$

$$\frac{V_2}{V_1} = \left( \frac{2.73}{1} \right)^2$$

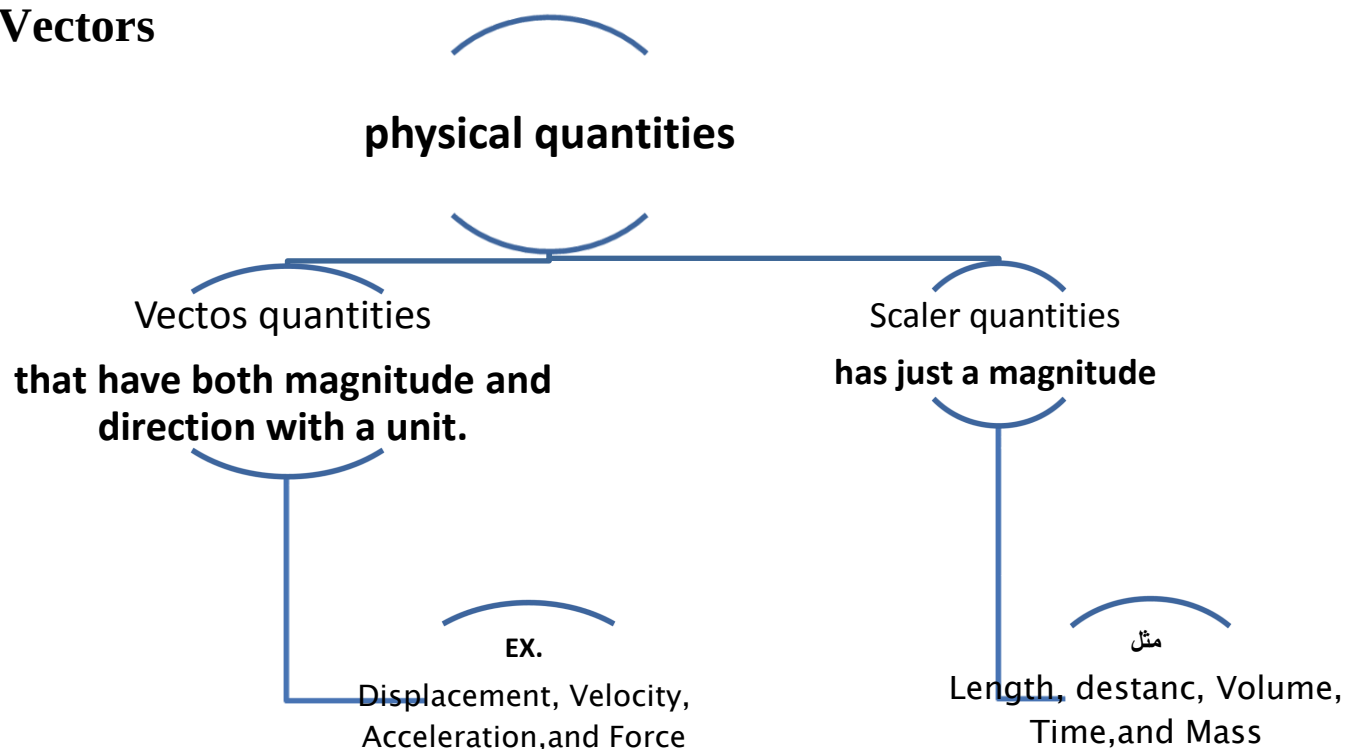
$$\frac{V_2}{V_1} = 7.4529 \approx 7.45$$

$$\frac{V_1}{V_2} = \frac{\pi r_1^2 h}{\pi r_2^2 h}$$

$$\frac{V_1}{V_2} = \left( \frac{r_1}{r_2} \right)^2$$

وبما أن

$$r_2 = 2.73 r_1$$

**Vectors****Vectors quantities properties**

- 1- A vector can be moved from its place to another place provided maintain both the amount and direction
- 2- Equivalent the vectors if they have same amount, and same direction, and the same unit of measurement.
- 3- The sum of two opposing vectors is zero
- 4- The vector subtraction process is a special case of collection To subtract a vector we combine with negative

This subtraction process is not interchangeable because

$$A - B \neq B - A$$

5- Multiply vector quantity in a scalar quantity Or the product of a vector division on a scalar quantity produces a vector quantity.

6- The process of vector collection is interchangeable

$$\vec{A} + \vec{B} = \vec{B} + \vec{A}$$

7- To collect vectors using Cartesian components If  $\vec{A} = (A_x, A_y, A_z)$   
and  $\vec{B} = (B_x, B_y, B_z)$

then

$$\begin{aligned}\vec{C} = \vec{A} + \vec{B} &= (A_x, A_y, A_z) + (B_x, B_y, B_z) \\ &= (A_x + B_x, A_y + B_y, A_z + B_z)\end{aligned}$$

**By another meaning**

The sum vector are the sum of the components of the individual vectors

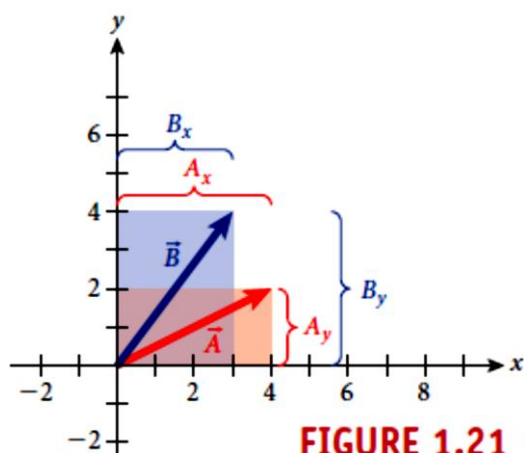
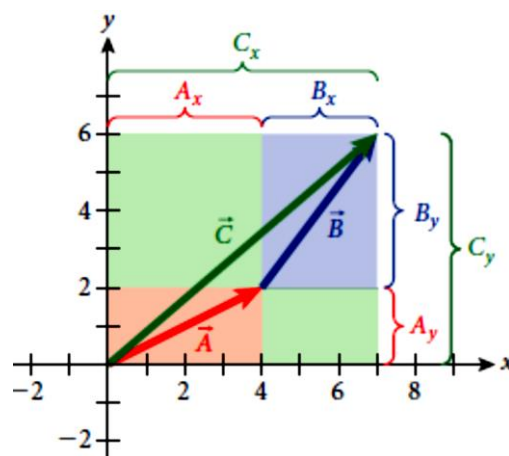


**FIGURE 1.21** Vector addition by components. (a) Components of vectors  $\vec{A}$  and  $\vec{B}$ ; (b) the components of the resultant vector are the sums of the components of the individual vectors.

$$C_x = (A_x + B_x)$$

$$C_y = (A_y + B_y)$$

$$C_z = (A_z + B_z)$$



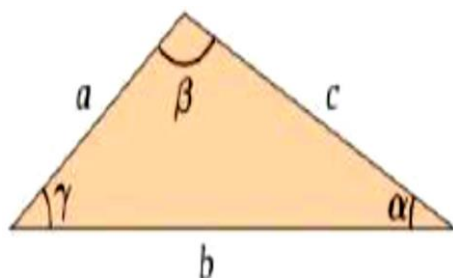
- Note that: Vector collection must have the same dimension and the same type

**For ex. : Do not collect the velocity vector with the displacement.**

س : في الشكل التالي  $a = 6.6 \text{ cm}$  ,  $b = 13.7 \text{ cm}$  ,  $c = 9.2 \text{ cm}$

ما قيمة الزاوية  $\gamma$  ؟

الحل :



$$c^2 = a^2 + b^2 - 2ab \cos \gamma$$

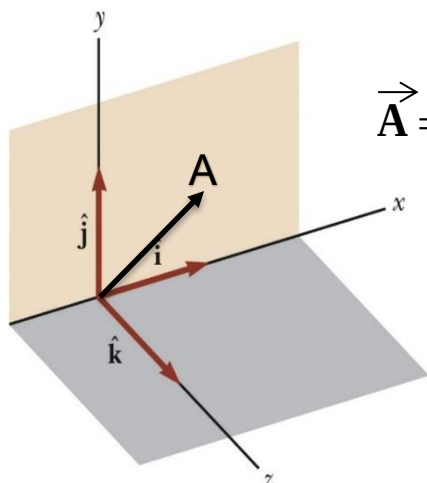
$$c^2 = a^2 + b^2 - 2ab \cos \gamma$$

$$2ab \cos \gamma = a^2 + b^2 - c^2$$

$$\cos \gamma = \frac{a^2 + b^2 - c^2}{2ab}$$

$$\gamma = \cos^{-1} \left( \frac{a^2 + b^2 - c^2}{2ab} \right)$$

$$\gamma = \cos^{-1} \left[ \frac{(6.6 \text{ cm})^2 + (13.7 \text{ cm})^2 - (9.2 \text{ cm})^2}{2(6.6 \text{ cm})(13.7 \text{ cm})} \right] = 35.83399^\circ \quad \gamma = 36^\circ$$

**Vector components: using**

$$\vec{A} = A_x \hat{x} + A_y \hat{y} + A_z \hat{z} = A_x \hat{i} + A_y \hat{j} + A_z \hat{k}$$

An orthogonal coordinate system

**Multiplication of a Vector with a scalar**

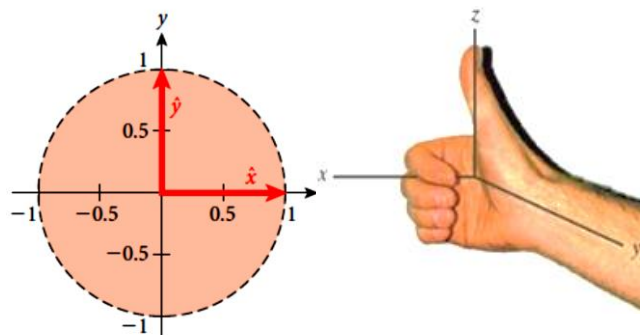
Multiplication of a vector by a negative scalar results in a vector pointing in the opposite direction

$$\vec{E} = s\vec{A} = s(A_x, A_y, A_z) = (sA_x, sA_y, sA_z).$$

$$E_x = sA_x$$

$$E_y = sA_y$$

$$E_z = sA_z.$$



(a)

**Unit Vectors**

There is a set of special vectors that make much of the math associated with vectors easier. Called unit vectors, they are vectors of magnitude 1 directed along the main coordinate axes of the coordinate system

$$\hat{x} = (1, 0, 0), \hat{y} = (0, 1, 0), \hat{z} = (0, 0, 1)$$

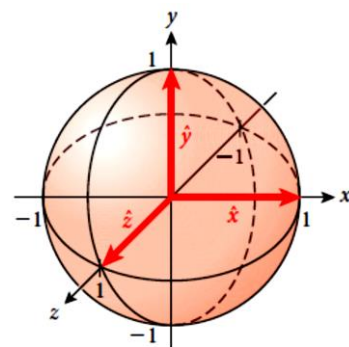
each unit vector is multiplied by the corresponding Cartesian component of the vector

$$\vec{A} = (A_x, A_y, A_z)$$

$$= (A_x, 0, 0) + (0, A_y, 0) + (0, 0, A_z)$$

$$= A_x (1, 0, 0) + A_y (0, 1, 0) + A_z (0, 0, 1)$$

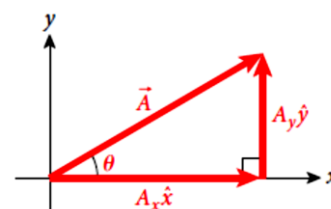
$$= A_x \hat{x} + A_y \hat{y} + A_z \hat{z}$$



(b)

In two dimensions, we have :

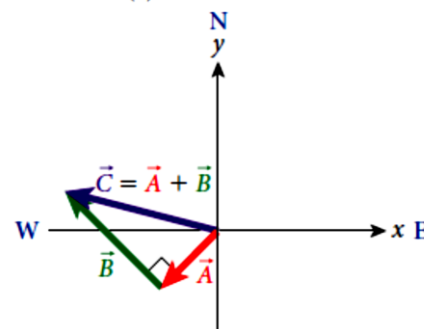
$$\vec{A} = A_x \hat{x} + A_y \hat{y}$$



(a)

**Q:** You are hiking in Florida Everglades heading southwest from your base camp, for 1.72 km . you reach a river that is too deep to cross ; so you make a 90° right turn and hike another 3.12 km to a bridge.

How far away are you from your base camp?



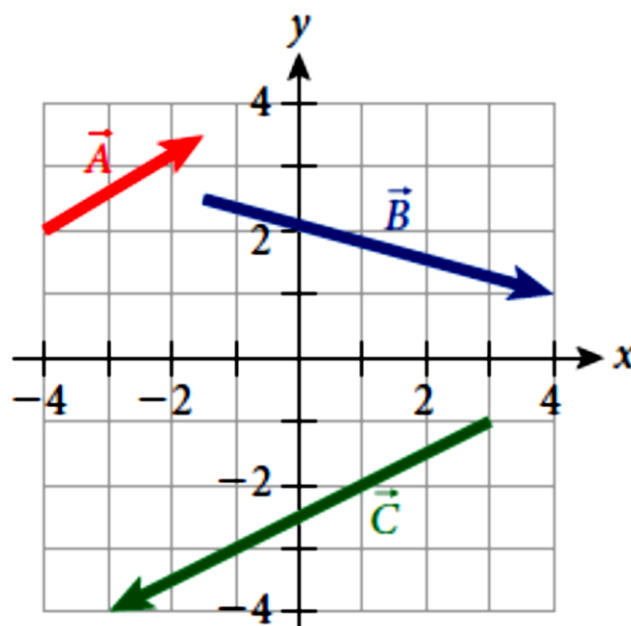
**O:** A position vector has a length of 40.0 m and is at an angle of 57.0° above the x-axis. Find the vector's components.

**Q1:** Write the vectors  $\vec{A}$ ,  $\vec{B}$ , and  $\vec{C}$  in Cartesian coordinates.

**Q2:** Calculate the length and direction of the vectors  $\vec{A}$ ,  $\vec{B}$ , and  $\vec{C}$ .

**Q3:** Add the three vectors  $\vec{A}$ ,  $\vec{B}$ , and  $\vec{C}$  graphically.

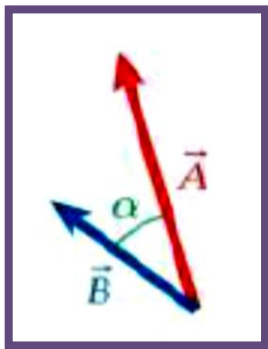
**Q3:** Determine the difference vector  $\vec{E} = \vec{B} - \vec{A}$  graphically.



## Scalar product for vectors      الضرب القياسي للمتجهات

The use of the larger dot (  $\cdot$  ) we often referred to the scalar product as the dot product

In definition of The scalar product  $\vec{A}, \vec{B}$



$$\vec{A} \cdot \vec{B} = |\vec{A}| |\vec{B}| \cos \alpha$$

$\alpha$  : The angle between  $\vec{A}, \vec{B}$       حيث

ملاحظات :

- The scalar product equal zero if the two vectors orthogonal
- The scalar product of any vector with itself, Equals the vector amount squar.

$$\vec{A} \cdot \vec{A} = A_x^2 + A_y^2 + A_z^2$$

$$\vec{A} \cdot \vec{A} = |\vec{A}| |\vec{A}| \cos \alpha = |\vec{A}| |\vec{A}| = |\vec{A}|^2$$

- The scalar product has the commutative property:  $\vec{A} \cdot \vec{B} = \vec{B} \cdot \vec{A}$

if :  $\vec{A} = (A_x, A_y, A_z), \quad \vec{B} = (B_x, B_y, B_z)$

$$\vec{A} \cdot \vec{B} = (A_x, A_y, A_z) \cdot (B_x, B_y, B_z)$$

$$= (A_x B_x + A_y B_y + A_z B_z)$$

- The length of vector  $|\vec{A}|$  :

$$|\vec{A}| = \sqrt{A_x^2 + A_y^2 + A_z^2}$$

- The angle  $\alpha$  :

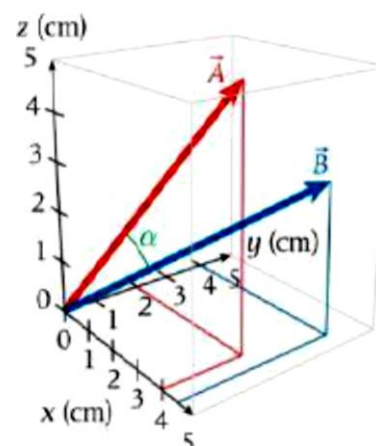
$$\cos \alpha = \frac{\vec{A} \cdot \vec{B}}{|\vec{A}| |\vec{B}|} \Rightarrow \alpha = \cos^{-1} \left| \frac{\vec{A} \cdot \vec{B}}{|\vec{A}| |\vec{B}|} \right|$$

- For the scalar product, the distributive property apply

$$\vec{A} \cdot (\vec{B} + \vec{C}) = \vec{A} \cdot \vec{B} + \vec{A} \cdot \vec{C}$$

**Q:** What is the angle  $\alpha$  between the two position vectors shown in the fig. 1.25

$$\vec{A} = (4.00, 2.00, 5.00), \quad \vec{B} = (4.50, 4.00, 3.00) \text{ cm}$$



For two vectors  $\vec{A} = (0, 1, 2) \text{ cm}$ ,  $\vec{B} = (2, 1, 0) \text{ cm}$  The scalar product equal:

- a) 3                      b) 6                      c) 0                      d) 1                      e) 2

For two vectors  $\vec{A} = (0, 1, 0) \text{ cm}$ ,  $\vec{B} = (1, 0, 0) \text{ cm}$  The scalar product equal:

- a) 3                      b) 2                      c) 0                      d) 1

### vector product ( cross product )

الضرب الاتجاهي

$$\vec{A} = (A_x, A_y, A_z), \quad \vec{B} = (B_x, B_y, B_z)$$

The vector product is defined as :

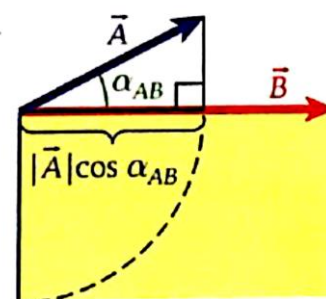
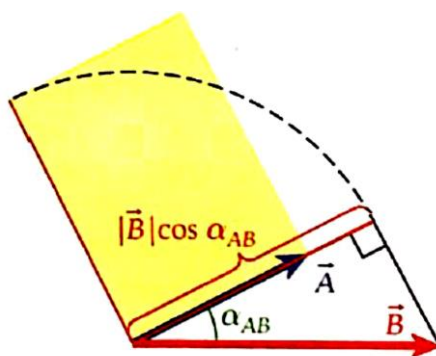
$$\vec{C} = \vec{A} \times \vec{B}$$

$$C_x = A_y B_z - A_z B_y$$

$$C_y = A_z B_x - A_x B_z$$

$$C_z = A_x B_y - A_y B_x$$

$$\bullet \quad |\vec{C}| = |\vec{A}| |\vec{B}| \sin \theta$$



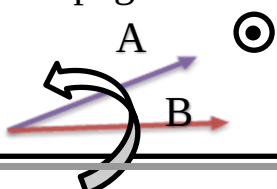
(a)

Direction of vector C

If rotation counter clockwise

Out the work page

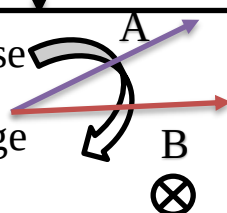
$$\vec{B} \times \vec{A}$$



If rotation clockwise

inside the work page

$$\vec{A} \times \vec{B}$$



- When  $\vec{A} \perp \vec{B}$ ,  $\theta = 90^\circ$

The vector product of A and B is at its **maximum**

- When  $\vec{A} \parallel \vec{B}$ ,  $\theta = 0^\circ$

The vector product of A and B is **zero**

- The vector product has not the commutative property

$$\vec{B} \times \vec{A} = -\vec{A} \times \vec{B}$$

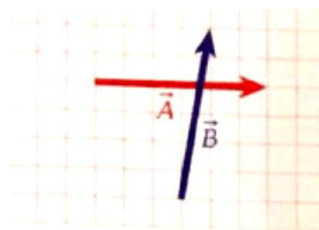
- The vector product of any vector with itself, Equal zero

$$\vec{A} \times \vec{A} = 0$$

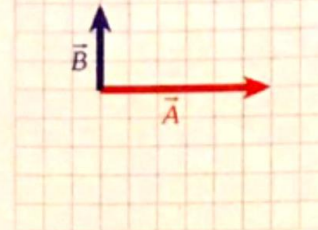
- 

$$\vec{A} \times (\vec{B} \times \vec{C}) = \vec{B}(\vec{A} \cdot \vec{C}) - \vec{C}(\vec{A} \cdot \vec{B})$$

**Q1:** Which of the six cases shown in the figure has the largest absolute value of the scalar product of the vectors  $\vec{A}$  and  $\vec{B}$ ?



(a)

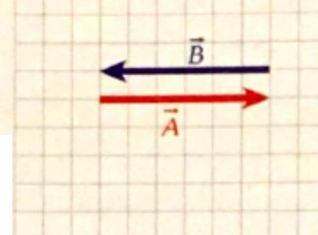


(b)

**Q2:** Which of the six cases shown in the figure has the smallest absolute value of the scalar product of the vectors  $\vec{A}$  and  $\vec{B}$ ?

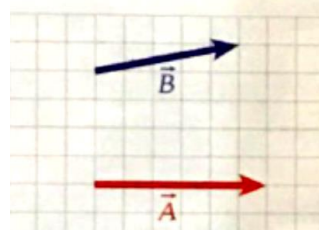


(c)

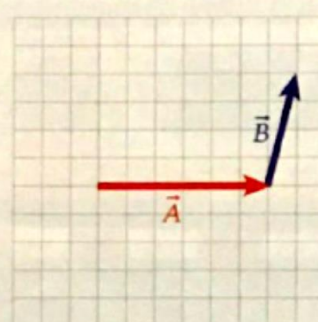


(d)

**Q3:** Which of the six cases shown in the figure has the largest absolute value of the vector product of the vectors  $\vec{A}$  and  $\vec{B}$ ?



(e)



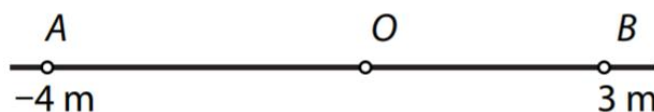
(f)

**Q4:** Which of the six cases shown in the figure has the smallest absolute value of the vector product of the vectors  $\vec{A}$  and  $\vec{B}$ ?

### Position vector

- If an object is located on a particular point on a line, we can denote this point with its **position vector (r)**,

For example:



- The position of the particle at  $B$  is 3 m.
  - The position of the particle at  $A$  is  $-4$  m.
- The position vector of an object Can change as a function of time  $r(t)$  : the object moves

### Position graph

From the graph the slope of the line = the velocity

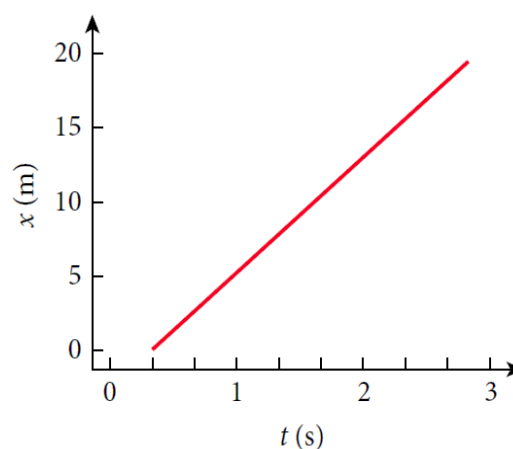


**FIGURE 2.3** Same graph as Figure 2.2b, but rotated so that the time axis is horizontal, and without the pictures of the car.

### Displacement Vs Distance

**Displacement** is the difference between

the final position vector,

$$\Delta \vec{r} = \vec{r}_2 - \vec{r}_1. \quad \Delta \vec{r}_{ba} = \vec{r}_b - \vec{r}_a = -(\vec{r}_a - \vec{r}_b) = -\Delta \vec{r}_{ab}$$

**Distance** is the absolute value of the displacement vector (the absolute value of displacement for each straight-line segment *in which the movement does not reverse direction*)

$$\ell = |\Delta \vec{r}|.$$

**average velocity,  $\bar{v}_x$ :**

the ratio of displacement per time interval

$$\bar{v}_x = \frac{\Delta x}{\Delta t}.$$

**instantaneous velocity,**

the time derivative of the displacement (a limit as the time interval approaches Zero)

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

**Speed**

is the absolute value of the velocity vector. For a moving object, speed is always positive.

$$\text{speed} \equiv v = |\vec{v}|$$

**average speed**

when a distance  $\ell$  is traveled during a time interval  $\Delta t$  is

$$\text{average speed} \equiv \bar{v} = \frac{\ell}{\Delta t}$$

- Speed refers to a scalar and velocity to a vector
- $v_x$  is the x – component of the velocity vector
- The change in position in a given time interval divided by that time interval

**Q:** During the time interval from 0.0 s to 10.0 s , the position vector of a car on a road is given by  $x(t) = 7.0 - 10.3 t + 1.2 t^2$  ,

- What is the car's velocity at  $t = 4.00$  s ?
- What is the car's average velocity during the period from  $t = 5.00$  s to  $t = 10.0$  s ?
- In which time the velocity reaches zero ?

**Q:** 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?

**Q:** The trajectory of an object is given by the equation

$$x(t) = (4.35\text{m}) (25.9\text{m/s}) t - (11.79\text{m/s}^2) t^2$$

- For which time  $t$  is the displacement  $x(t)$  at its maximum?
- What is this maximum value?

- Average Acceleration Vector**

Rate of change of velocity

$$\bar{a} = \frac{\Delta \vec{v}}{\Delta t} = \frac{\vec{v}_f - \vec{v}_0}{t_f - t_0}$$

- Unit:  $m/s^2$
- If the acceleration is same direction as motion, then the object is increasing speed (**rising up**).
- If the acceleration is opposite direction as motion, then the object is decreasing speed (**slowing down**).

**Accelerated motion**

**1- Constant Acceleration**

- 1)  $v = v_0 + at$
- 2)  $x = x_0 + v_0 t + \frac{1}{2} at^2$
- 3)  $v^2 = v_0^2 + 2a(x - x_0)$
- 4)  $x = x_0 + \bar{v}t$
- 5)  $\bar{v} = \frac{1}{2} (\vec{v}_0 + \vec{v})$

**2- variable acceleration**

- 1)  $x = x_0 + \int_{v_0}^v \vec{v} dt$
- 2)  $v = v_0 + \int_{a_0}^a a dt$

**Q1:** A plane starting from rest accelerates to  $40 m/s$  in  $10 s$ . How far did the plane travel during this time?

**Q2:** To avoid an accident, a car decelerates at  $0.50 m/s^2$  for  $3.0 s$  and covers  $15 m$  of road. What was the car's initial velocity?

**Q3:** A cheetah is walking at  $1.0 m/s$  when it sees a zebra  $25 m$  away. What acceleration would be required to reach  $20.0 m/s$  in that distance?

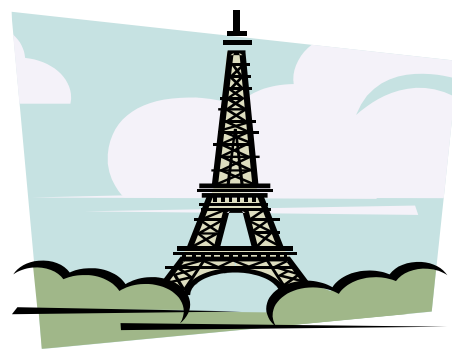
**Q4:** The position of a race car on a straight track is given as  $x = 2.0t^3 + 3t^2 + 4$ ,

- a) What is the car's position between  $t_1 = 4.0$  s and  $t_2 = 9.0$  s?
- b) What is the average speed between  $t = 4.0$  s and  $t = 9.0$  s?
- c) What is the acceleration at  $t = 6.0$  s?

### Free Fall

**Q5:** You drop a coin from the top of a hundred story building (1000 m). If you ignore air resistance,

- 1-how fast will it be falling right before it hits the ground?
- 2- How long does it take to hit the ground?



**Q6:** A baseball is hit straight up into the air. If the initial velocity was 30 m/s, how the maximum Hight will the ball go?

**Q7:** An object is thrown vertically and has an upward velocity of 25 m/s when it reaches one fourth of its maximum height above its launch point.

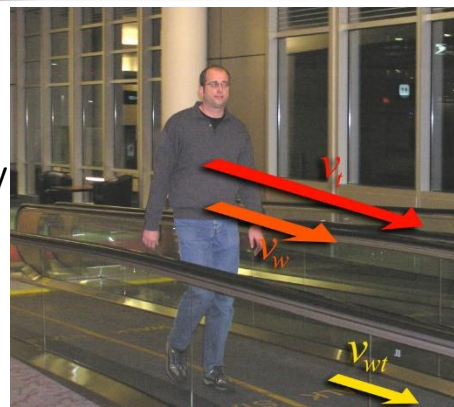
What is the initial (launch) speed of the object?

**Relative velocity**

Velocity always defined relative to reference frame

An airport walkway moves at 3 mph. A man walks at a leisurely pace of 2 mph.

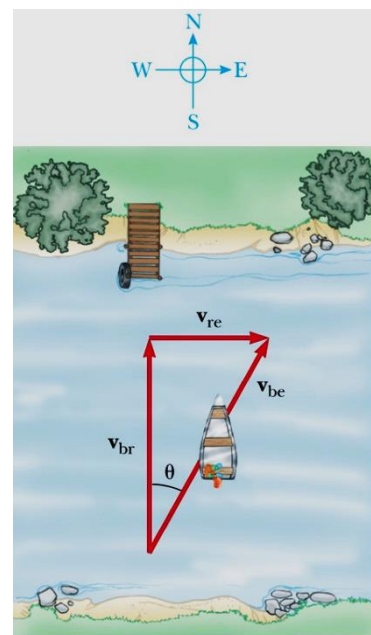
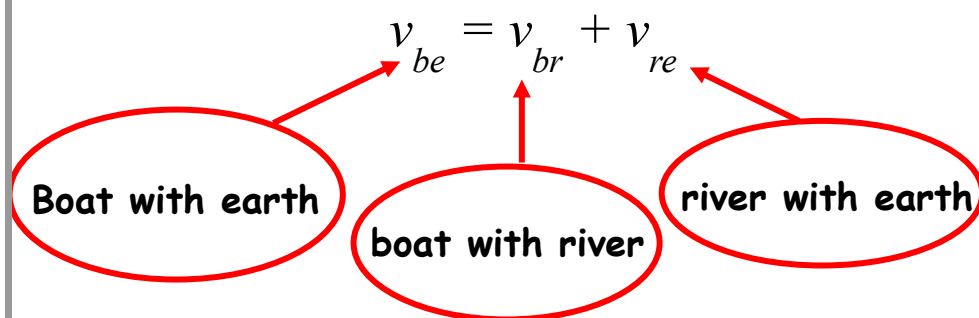
a) If he walks on the walkway in the same direction as the walkway, what is his speed as seen from the ground?



b) If he walks on the walkway in the opposite direction as the walkway, what is his speed as seen from the ground?

- Sum velocities as

velocity vectors relative to ground = velocity relative to medium + velocity of medium.



**Q:** An airplane is capable of moving 200 mph in still air.

The plane points directly east, but a 50 mph wind from the north distorts his course.

- What is the resulting ground speed?
- What direction does the plane fly relative to the ground?

206.2 mph

14.0° . south of east

## - Position vector

$$\vec{r} = (x, y, z) = x\hat{x} + y\hat{y} + z\hat{z}.$$

## - Velocity vector

$$v_x = \frac{dx}{dt}, \quad v_y = \frac{dy}{dt}, \quad v_z = \frac{dz}{dt}.$$

## - Acceleration vector

$$a_x = \frac{dv_x}{dt}, \quad a_y = \frac{dv_y}{dt}, \quad a_z = \frac{dv_z}{dt}.$$

## Projectile Motion

1- Objects in flight only under influence of **gravity**

2- **x** and **y** components are independent

Time is only quantity that is the same in both dimensions

3- **x**-component velocity constant since nothing pulling it

sideways

$$\text{Use } x = v_{0x}t$$

• **y**-component changes because gravity pulling it down

Use equations of kinematics

1-  $v = v_0 + at$

2-  $x = x_0 + v_0t + \frac{1}{2}at^2$

3-  $v^2 = v_0^2 + 2a(x - x_0)$

4-  $x = x_0 + \bar{v}t$

5-  $\bar{v} = \frac{1}{2} (\vec{v}_0 + \vec{v})$

1)  $\Delta x = v_{0x}t$

2)  $v_x = v_{0x} = v_0 \cos \theta = \text{constant}$

$$|\vec{v}| = \sqrt{v_x^2 + v_y^2} = \sqrt{v_{x0}^2 + v_{y0}^2 - 2g(y - y_0)} = \sqrt{v_0^2 - 2g(y - y_0)}$$

- If the starting and ending heights are the same,

the distance the object goes can be found with the range equation

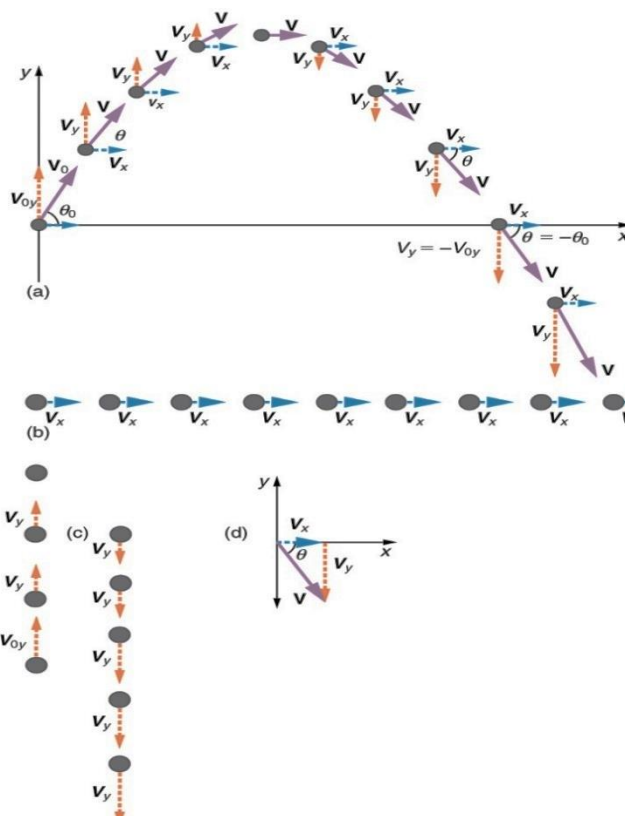
$$R = \frac{v_0^2 \sin 2\theta}{g}$$

the maximum height

$$H = \frac{v_0^2 \sin^2 \theta}{2g}$$

flying time

$$t = \frac{2v_0 \sin \theta}{g}$$



**Q:** If the baseball comes off the bat with a launch angle of  $35^\circ$  and an initial speed of  $49.2 \text{ m/s}$ ,

- a) How far will the ball fly? Range.
- b) How long will it be in the air? total time
- c) What will its vertical velocity be at the top of its trajectory?
- d) What will its horizontal velocity be at the top of its trajectory?
- e) What will its speed be at the top of its trajectory? Hint:
- f) What will its speed be when it lands?

**Q:** A truck ( $v_x = 11.2 \text{ m/s}$ ) turned a corner too sharp and lost part of the load. A falling box will break if it hits the ground with a velocity greater than  $15 \text{ m/s}$ . The height of the truck bed is  $1.5 \text{ m}$ .

- a) Will the box break?

**Q:** An archer shoots an arrow from a height of  $1.14 \text{ m}$  above ground with an initial velocity of  $47.5 \text{ m/s}$  and an initial angle of  $35.2^\circ$  above the horizontal.

- a) At what time after the release of the arrow from the bow will the arrow be flying exactly horizontally?

**Q:** An object is launched at a speed of  $20.0 \text{ m/s}$  from the top of a tall tower. The height  $y$  of the object as a function of the time  $t$  elapsed from launch is

$$y(t) = -4.9t^2 + 19.32t + 60,$$

where  $h$  is in meters and  $t$  is in seconds. Determine:

- a) the height  $H$  of the tower;
- b) the launch angle;
- c) the horizontal distance traveled by the object before it hits the ground.

## Forces and Motion

- What is a force?
- **Force** is an external effect on the system (object) and change object's motion ( $a \neq 0$ ) or changes it's shape

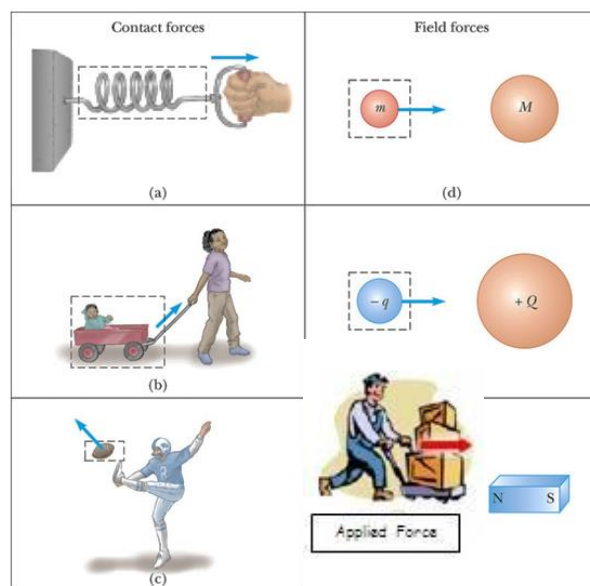
- 1- **contact force**: in which one object has to be in contact (touch) with another object to exert a force on it

### Examples :

pull force / push force / friction force (study later) / air resistance (kind of friction) spring force has a special property of being linearly dependent on the change in length of the spring / normal force / drag force / tension force

- 2- **Field force (fundamental force)**: is the force exerted between the two objects without touching (contact)

Example : gravitational force / electric force / magnetic force /electromagnetic force/ weak or strong nuclear force



## Newton's first law and inertia

*"If the net force exerted on an object is zero, its velocity remains constant (both magnitude and direction)."*



Objects at rest feel no net force

Objects moving with constant velocity feel no net force

No net force means  $\Sigma F = 0$

## Mass ( m )

- A measure of the resistance of an object to changes in its motion due to a force
- Scalar
- SI units are kg

**Newton's Second Law**

- "Acceleration is proportional to net force and inversely proportional to mass."

$$\Sigma \mathbf{F} = m \mathbf{a}$$

$$\mathbf{F} = m \mathbf{a}$$

$$1 \text{ N} = 1 \frac{\text{kg} \cdot \text{m}}{\text{s}^2}$$

$$|\vec{a}| = g$$

$$\Rightarrow \text{weight} = \text{mass} \cdot g$$

Weight = magnitude of Gravitational Force on an object near the surface of the Earth

- Weight is different on surface of other planets/moons.

Mass is same everywhere

**Newton's Third Law**

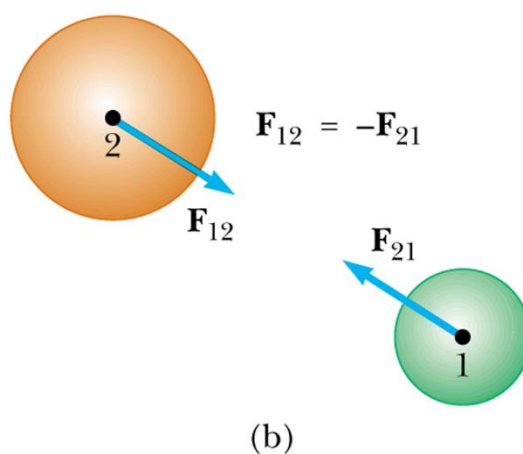
- "Single isolated force cannot exist"

For every action there is an equal and

opposite reaction"

$$\vec{F}_{12} = -\vec{F}_{21}$$

Force on "1" due to "2"



- Action and Reaction Forces act on different objects

$$\vec{n} = -\vec{n}'$$

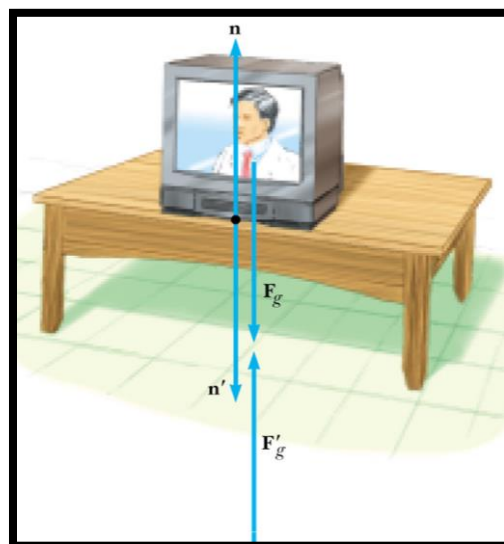
$$F_g = -F'_g$$

$n$  = Normal force of table holding up TV

$\vec{n}'$  = Normal force of TV pushing down on table

$F_g$  = Weight of TV (attracted to Earth)

$F'_g$  = Gravitational force on Earth (attracted to TV)



$$\sum \vec{F} = 0$$

Object is at rest or moving with constant velocity

### Rules for Ropes and Pulleys

- Force from rope points **AWAY** from object

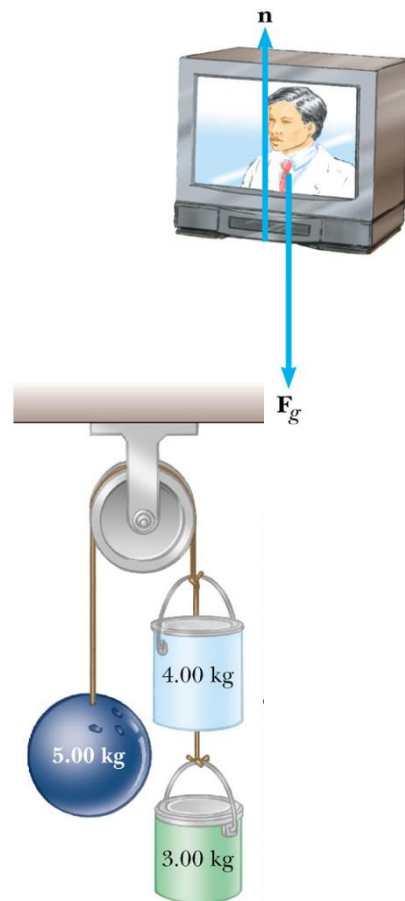
(Rope can only pull)

- Magnitude of the force is Tension

Tension is same everywhere in the rope

- Tension does not change when going over pulley

Approximations: Neglect mass of rope and pulley,  
neglect friction in pulley



**Q1:** I pull a 5 kg mass up with a rope, so that it accelerates  $2 \text{ m/s}^2$ .

What is the tension in the rope?

**Q2:** Look at the image and then answer :

- Find acceleration
- Find  $T$ , the tension above the bowling ball
- Find  $T_3$ , the tension in the rope between the pails
- Find force ceiling must exert on pulley



- $a = g/6 = 1.635 \text{ m/s}^2$
- $T = 57.2 \text{ N}$
- $T_3 = 24.5 \text{ N}$
- $F_{\text{pulley}} = 2T = 114.5 \text{ N}$

Which statements are correct?

Assume the objects are static.

1-  $T_1$  is \_\_\_\_\_  $T_2$

A) Less than

B) Equal to

C) Greater than

2-  $T_2$  is \_\_\_\_\_  $T_3$

A) Less than

B) Equal to

C) Greater than

3-  $T_1$  is \_\_\_\_\_  $Mg$

A) Less than

B) Equal to

C) Greater than

4-  $T_1 + T_2$  is \_\_\_\_\_  $Mg$

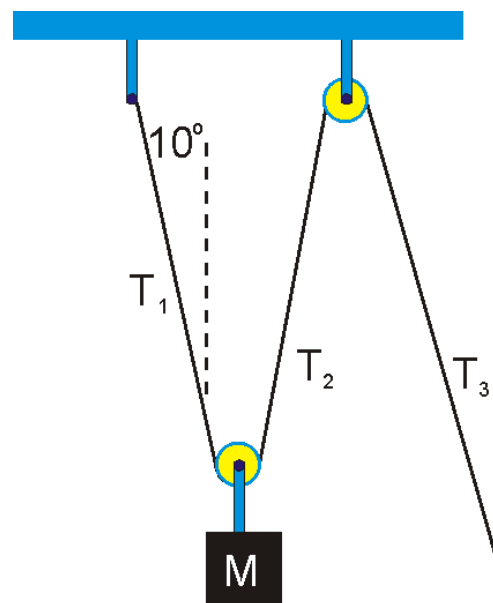
A) Less than

B) Equal to

C) Greater than

• The difference between mass and weight show in table below

|                                           | Weight ( $F_g$ )                                                                                                                      | Mass (m)                           |
|-------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|
| Definition                                | The force exerted from earth to the object                                                                                            | Amount of the matter in the object |
| Unite                                     | N                                                                                                                                     | Kg                                 |
| Scale device                              | Spring balance                                                                                                                        | Simple balance                     |
| Direction                                 | Downward                                                                                                                              | No direction                       |
| What will happen If the location change ? | Change/ because if the object very far from the center of the planet it's weight decreases because the gravity acceleration decreases | Not change                         |



$$\cos(10^\circ) = 0.985$$

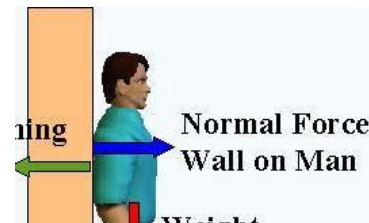
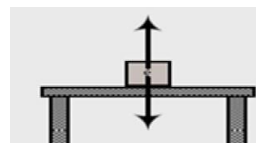
$$\sin(10^\circ) = 0.173$$

**Normal force (N):** is the force exerted from surface to the object( system)

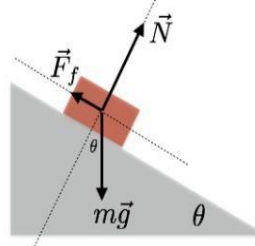
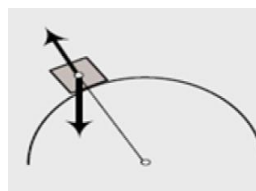
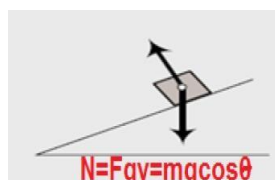
- always it is a straight line make 90 degree with the surface and always goes outward the surface

**Examples:**

- if there is a horizontal surface , the normal force will be vertical
- if there is a vertical surface , the normal force will be horizontal
- if there is a incline surface , the normal force will be incline to make 90 with the surface



**Q:** Look to the figure below and find the normal force in each picture then compare it with gravity force ( assume the mass of the system (box) = 7kg)



## Friction force

It is an interaction between the object (system) atoms and surface atoms

- 1- Static friction:  $F_s$
- 2- Kinetic friction:  $F_k$

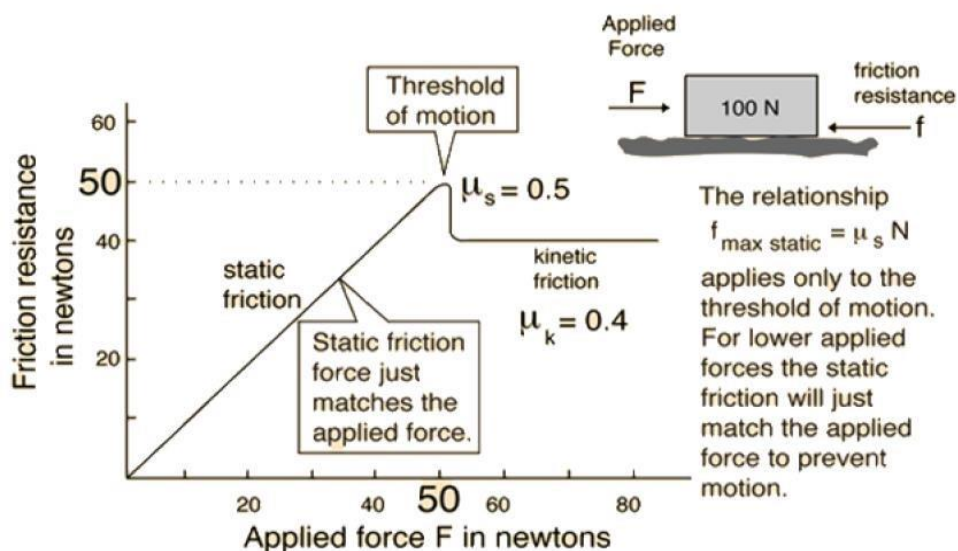
The **coefficient of friction** ( $\mu$ )

$$\mu = \frac{F_f}{N}$$

$$0 < \mu < 1$$

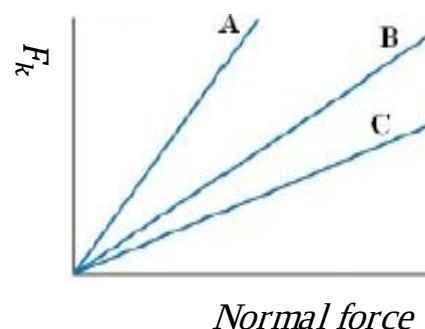
$$\mu_s = \frac{F_{s,max}}{N}$$

$$\mu_k = \frac{F_k}{N}$$



**Q1:** Which quantity in physics represents the slope ?

**Q1:** Which one (A,B,C) has the biggest ( $\mu_k$ ) coefficient kinetic friction ?



**Q2) If you applied force on an object has mass 25kg look to graph 2 and answer the following question**

1- Find the coefficient friction when the object in threshold of motion

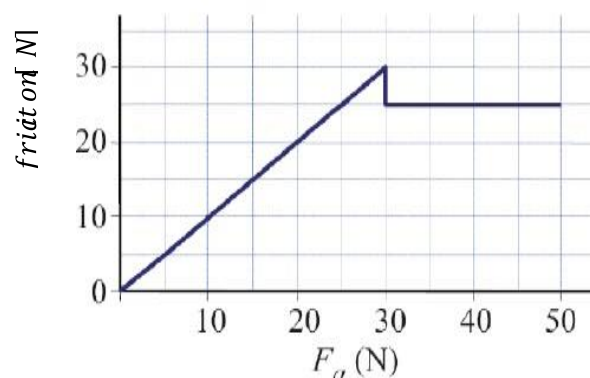
$$\mu_s = \frac{f_{s,max}}{F_n} = \frac{f_{s,max}}{F_g} = \frac{f_{s,max}}{mg} = \frac{30}{25 \times 9.81} = 0.12$$

2- Find the coefficient friction when the object move

$$\mu_s = \frac{f_k}{F_n} = \frac{f_k}{F_g} = \frac{f_k}{mg} = \frac{25}{25 \times 9.81} = 0.1$$

3- What is the acceleration when he person applied 40N?

$$a = \frac{F_{net}}{m} = \frac{F_a - f_k}{m} = \frac{40 - 25}{25} = 0.6 \text{ m/s}^2$$



- **Drag force** is the force exerted from the fluid (liquid or gas) to the object moving in the fluid and always the drag force is opposite direction to the object motion
- **Tribology** is the science of friction
- in general, the magnitude of friction force in liquid or gases will be expressed as

$$F_f = K_0 + K_1 v + K_2 v^2 + \dots$$

- When velocity for the object increases the drag force as air resistance will increase, we can neglect the linear term from the friction equation when the velocity is high so the drag force equation

$$F_f = F_{drag} = K v^2$$

- For low velocity friction equation will be  $F_f = K v$  this form applies biological process as bacteria move through liquid, and we will use it when analyzing the sinking of an object in a fluid as a small stone or fossil shell in water
- **Air resistance** is an example of drag force because always air resistance opposes to the object motion

### Free body diagram for the person falling

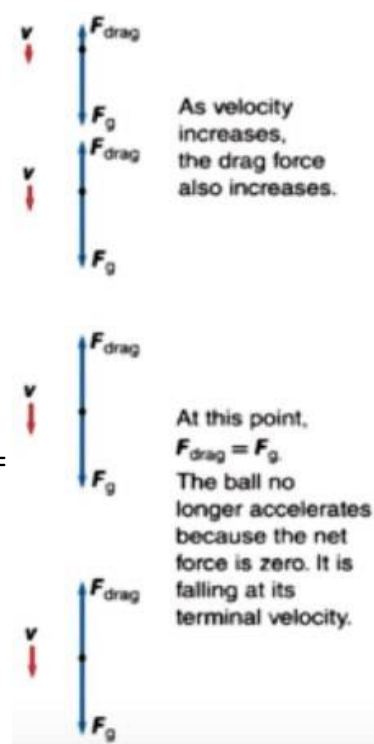
- The drag force in this example is the air resistance
- When the person goes down his weight ( $F_g$ ) does not change
- When the person goes down the velocity increases so the drag force increases, too
- When the person goes down  $F_{net}$  decreases because drag force increases

$$F_{net} = F_d - F_g$$

- **Terminal velocity** is a constant velocity when  $F_d = F_g$  and  $F_{net} = 0$
- the terminal speed equation  $F_{drag} = F_g = K v^2$

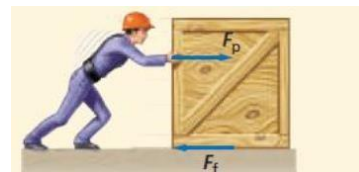
$$v_{terminal} = \sqrt{\frac{mg}{K}}$$

\* The factors effect on the constant of drag force  $K = \frac{1}{2} C_p A \rho$



## Problems

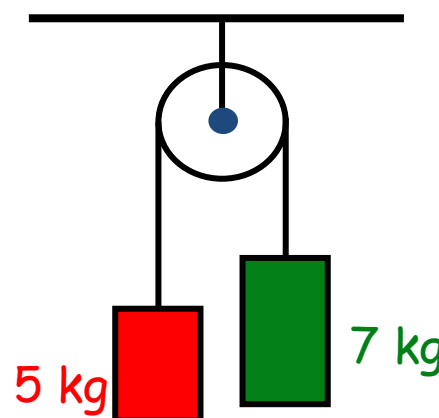
**Q1:** You push a 25 kg wooden box across a wooden floor at a constant speed of 1m/s how much force do you exert on the box if the coefficient of kinetic friction is 0.33?



**Q2:** One student applied a force 40N on a rough surface with  $45^\circ$  above the horizontal ( north to east) ,what is the acceleration if the coefficient of kinetic friction is 0.13?

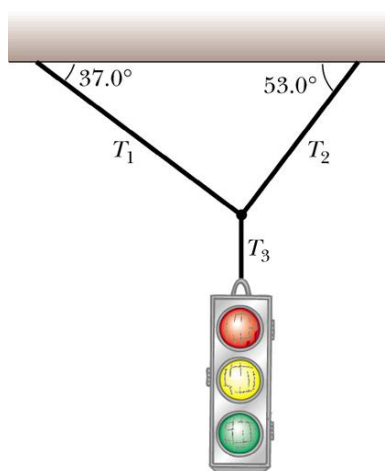
**Q3: Atwood Machine**

- Find acceleration
- Find  $T$ , the tension in the string
- Find force ceiling must exert on pulley

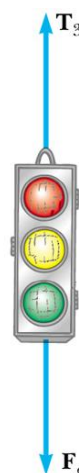


- $a = g/6 = 1.635 \text{ m/s}^2$
- $T = 57.2 \text{ N}$
- $F_{\text{pulley}} = 2T = 114.5 \text{ N}$

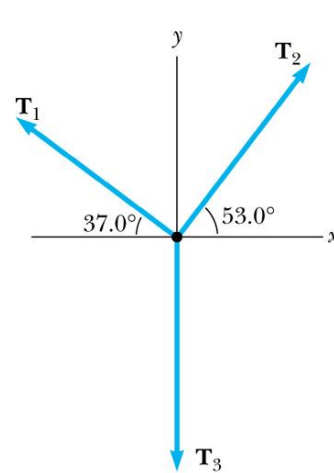
**Q4:** Given that  $M_{\text{light}} = 25 \text{ kg}$ , find all three tensions



(a)



(b)

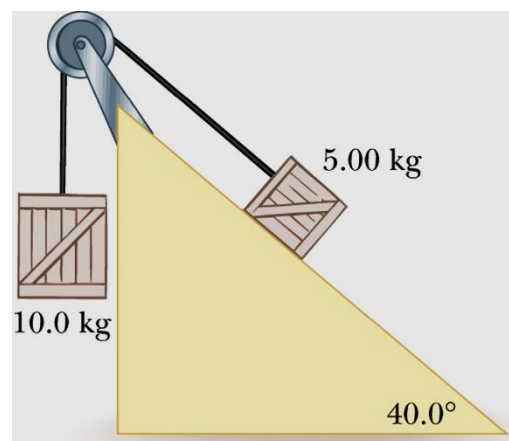


(c)

$$T_3 = 245.3 \text{ N}, T_1 = 147.4 \text{ N}, T_2 = 195.7 \text{ N}$$

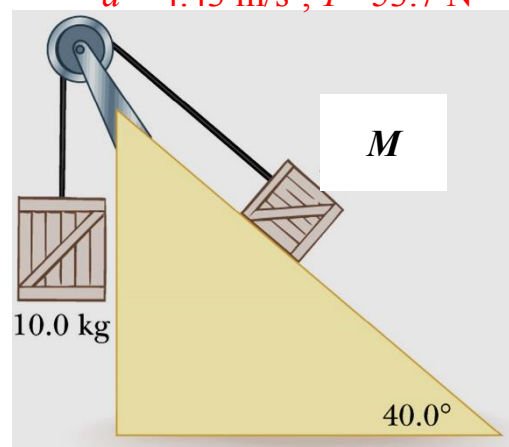
**Q5:** Find

- 1- the acceleration
- 2- the tension



$$a = 4.43 \text{ m/s}^2, T = 53.7 \text{ N}$$

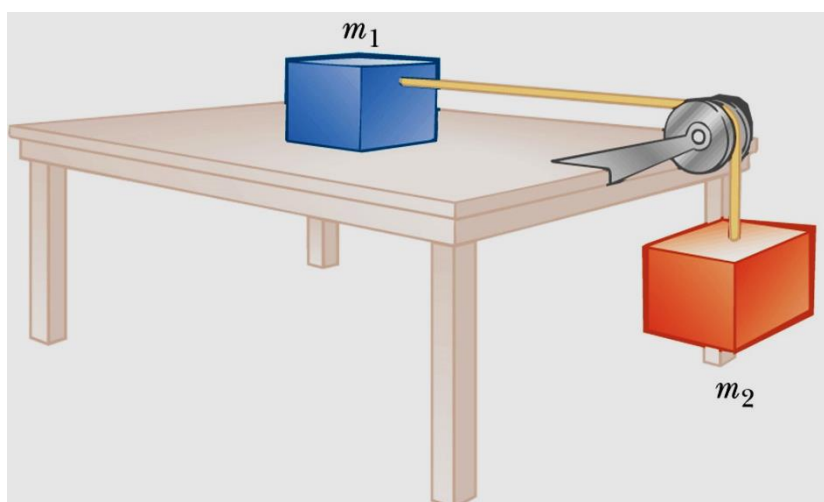
**Q6:** Find  $M$  such that the box slides at constant  $v$



$$M = 15.6 \text{ kg}$$

**Q7:** Given  $m_1 = 10 \text{ kg}$  and  $m_2 = 5 \text{ kg}$ :

- a) What value of  $\mu_s$  would stop the block from sliding?
- b) If the box is sliding and  $\mu_k = 0.2$ , what is the acceleration?
- c) What is the tension of the rope?



$$\text{a) } \mu_s = 0.5 \quad \text{b) } a = 1.96 \text{ m/s}^2 \quad \text{c) } T = 39.25 \text{ N}$$