

Notes CH.(5): Force and Motion I (القوة والحركة)

Newton's laws

Newton's 1st law

$$\vec{F}_{net} = 0$$

$$\sum F_x = 0, \quad \sum F_y = 0$$

ويعرف الجسم بأنه في حالة اتزان (equilibrium) والتي لها ثلاثة حالات



-1- الجسم ساكن

$$v = 0 \rightarrow a = 0$$

-2- الجسم يتحرك بسرعة منتظمة

$$v = \text{Constant}$$

$$\rightarrow a = 0$$

-3- الجسم يكون تحت تأثير مجموع قوى محصلتها = صفر

$$F_1 - F_2 = 0$$



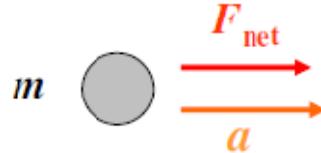
Newton's 2nd law

$$\vec{F}_{net} = \sum \vec{F} = m \vec{a}$$

$$\begin{aligned} F_{net,x} &= \sum F_x = m a_x \\ F_{net,y} &= \sum F_y = m a_y \end{aligned}$$

اتجاه التسارع دائماً في اتجاه

محصلة القوى

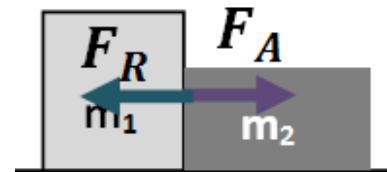


Newton's 3rd law

$$\vec{F}_{action} = -\vec{F}_{reaction}$$

(equal in magnitudes and opposite in directions)

$$|F_{action}| = |F_{reaction}|$$



The force is vector quantity, has both magnitude and direction

القوة كمية متوجهة لها مقدار واتجاه

القوة :

The unit of force is the Newton (N). $1 \text{ N} = 1 \text{ kg m/s}^2$
 $|F(N)| = m(\text{kg}) \times a (\text{m/s}^2)$

A mass is scalar quantity

الكتلة كمية قياسية

أما الوزن فهو قوة الجاذبية المؤثرة على جسم ما، وحدته وحدة قوة أي نيوتن.

The unit of weight is Newton (N)

$$|W| = |Fg|$$

Exp. (1): Three forces act on a particle of mass (m): $\vec{F}_1 = 80i + 60j$ and $\vec{F}_2 = 40i + 100j$. If the particle moves with constant speed of 4m/s. then \vec{F}_3 is

(a) $80i + 60j$

(b) $80i - 60j$

(c) $-80i + 60j$

(d) $-120i - 160j$

Solution:

$$v = \text{constant} \rightarrow a = 0 \rightarrow \vec{F}_{\text{net}} = 0$$

$$\vec{F}_1 + \vec{F}_2 + \vec{F}_3 = 0$$

$$\begin{aligned} \rightarrow \vec{F}_3 &= -\vec{F}_1 - \vec{F}_2 \\ &= -(80i + 60j) - (40i + 100j) = (-80 - 40)i + (-60 - 100)j \\ &= -120i - 160j \end{aligned}$$

Exp. (2): Two forces $\vec{F}_1 = 20i$ (N) and $\vec{F}_2 = 48j$ (N) are applied to move a 2 kg box. Find the magnitude and direction of the acceleration.

Solution:

$$\vec{F}_{\text{net}} = m \vec{a} \rightarrow \vec{F}_1 + \vec{F}_2 = m \vec{a}$$

$$20i + 48j = 2 \vec{a} \rightarrow \vec{a} = 10i + 24j$$

$$\text{The magnitude of } \vec{a} = |\vec{a}| = \sqrt{a_x^2 + a_y^2} = \sqrt{10^2 + 24^2} = 26 \text{ m/s}^2$$

$$\begin{aligned} \text{The direction of } \vec{a} \rightarrow \theta &= \tan^{-1} \frac{a_y}{a_x} \\ &= \tan^{-1} \frac{24}{10} = 67^\circ \end{aligned}$$

Exp. (3): Only two Forces are acting on a particle of mass 2 kg that moves with an acceleration of 3 m/s^2 in the positive direction of y- axis. If $\vec{F}_1 = 8i$ (N), the magnitude of \vec{F}_2 is

(a) 12N

(b) 10N

(c) 17N

(d) 15N

Solution:

$$m = 2 \text{ kg}, \vec{a} = 3j, F_1 = 8i, F_2 = ???$$

$$\vec{F}_1 + \vec{F}_2 = m \vec{a}$$

$$8i + F_2 = 2 \times 3j$$

$$F_2 = -8i + 6j$$

$$|F_2| = \sqrt{8^2 + 6^2} = 10 \text{ N}$$

Exp. (4): Two forces act upon a 5.0 kg box. One of the forces is $F_1 = (6.0 \text{ i} + 8.0\text{j}) \text{ N}$. If the box moves at a constant velocity of $(1.6 \text{ i} + 1.2 \text{j}) \text{ m/s}$, what is the second force?

Solution:

$$V = \text{constant} \rightarrow a=0$$

$$\vec{F}_1 + \vec{F}_2 = 0 \rightarrow \vec{F}_2 = -\vec{F}_1 = -6.0 \text{ i} - 8.0\text{j}$$

Exp. (5): There are three forces on the 2 kg box shown in the figure. If the box moves with constant acceleration $\vec{a} = 3i - 4j$. Find \vec{F}_3 .

$$F_1 = 20\text{N} \rightarrow \vec{F}_1 = 20i$$

$$F_2 = 30\text{N}, \theta = 30^\circ$$

$$F_{2x} = -30 \cos(30) = -26, F_{2y} = 30 \sin(30) = 15 \rightarrow \vec{F}_2 = -26i + 15j$$

$$\sum F = m a$$

$$\vec{F}_1 + \vec{F}_2 + \vec{F}_3 = m \vec{a}$$

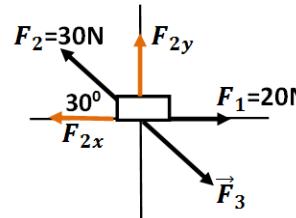
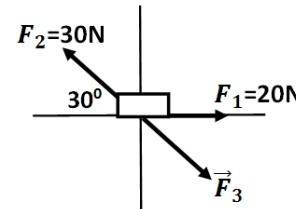
$$(20i) + (-26i + 15j) + \vec{F}_3 = 2 \times (3i - 4j)$$

$$(-6i + 15j) + \vec{F}_3 = (6i - 8j)$$

$$\vec{F}_3 = (6i - 8j) - (-6i + 15j) = (12i - 23j)$$

$$|F_3| = \sqrt{12^2 + 23^2} = 26 \text{ N}$$

$$\theta = \tan^{-1} \frac{F_{3y}}{F_{3x}} = \tan^{-1} \frac{-23}{12} =$$



Exp. (6): A force accelerates a 5kg particle from rest to a speed of 12 m/s in 4s. What is the magnitude of this force?

Solution:

$$m = 5\text{kg}, \quad v_0 = 0 \text{ (rest)}, \quad v = 12 \text{ m/s}, \quad t = 4\text{s}, \quad F = ???$$

نستخدم قانون نيوتن الثاني لإيجاد القوة

$$F = m \times a$$

ولكن قيمة التسارع غير معطاة في السؤال

لذلك نجد قيمة التسارع باستخدام معادلات الحركة عندما يكون التسارع ثابت

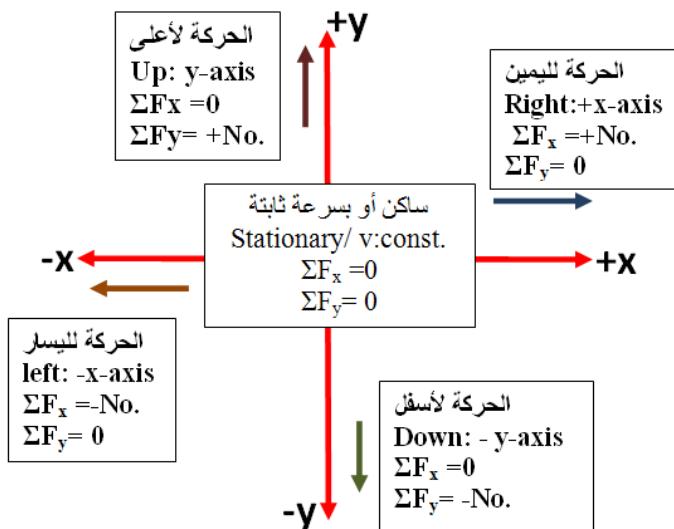
$$v = v_0 + at \rightarrow 12 = 0 + a \times (4)$$

$$a = 12/4 = 3 \text{ m/s}^2$$

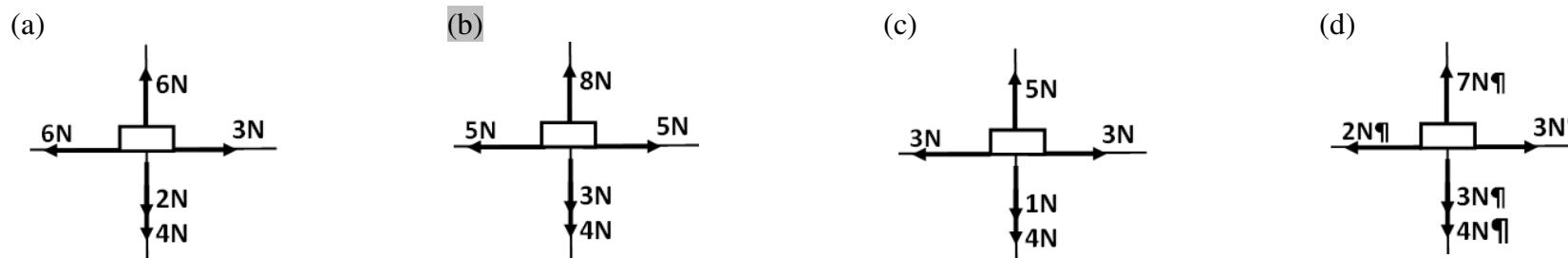
وبالتالي

$$F = m a = 5 \times 3 = 15 \text{ N}$$

هناه فرhan



Exp. (7): In which figure of the following the particle moves up if it starts from rest?



Solution:

Up= + y-axis $\rightarrow \Sigma F_x = 0, \Sigma F_y = + N_0$.

(a)
 $\Sigma F_x = 3 - 6 = -3$
 $\Sigma F_y = 6 - 2 - 4 = 0$

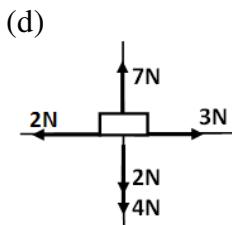
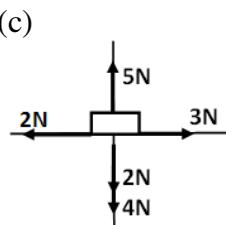
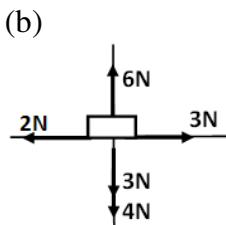
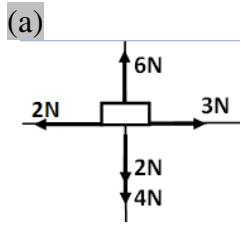
(b)
 $\Sigma F_x = 5 - 5 = 0$
 $\Sigma F_y = 8 - 3 - 4 = +1$

(c)
 $\Sigma F_x = 3 - 3 = 0$
 $\Sigma F_y = 5 - 1 - 4 = 0$

(d)
 $\Sigma F_x = 3 - 2 = +1$
 $\Sigma F_y = 7 - 3 - 4 = 0$

هناه فرhan

Exp. (8): In which figure of the following the y-component of the net Force is zero?



Solution:

$$\Sigma F_y = 0.$$

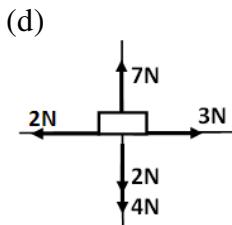
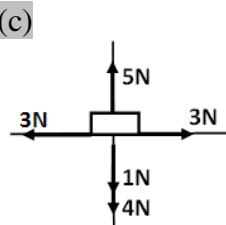
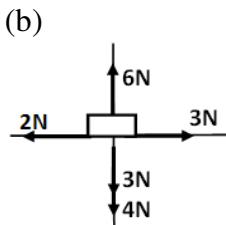
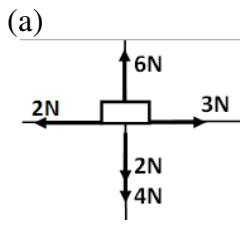
(a) $\Sigma F_y = 6 - 2 - 4 = 0$

(b) $\Sigma F_y = 6 - 3 - 4 = -1$

(c) $\Sigma F_y = 5 - 2 - 4 = -1$

(d) $\Sigma F_y = 7 - 2 - 4 = +1$

Exp. (9): In which figure of the following the particle moves with constant velocity?



Solution:

$$v = \text{constant} \rightarrow a=0 \rightarrow \Sigma F_x = 0, \Sigma F_y = 0.$$

(a) $\Sigma F_x = 3 - 2 = +1$
 $\Sigma F_y = 6 - 2 - 4 = 0$

(b) $\Sigma F_x = 3 - 2 = -1$
 $\Sigma F_y = 6 - 3 - 4 = -1$

(c) $\Sigma F_x = 3 - 3 = 0$
 $\Sigma F_y = 5 - 1 - 4 = 0$

(d) $\Sigma F_x = 3 - 2 = 1$
 $\Sigma F_y = 7 - 2 - 4 = +1$

Exp. (10): In the figure the net force on the block is:

(a) 1N-right

(b) 6N- up

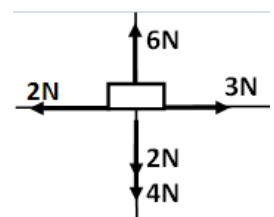
(c) 2N - left

(d) 4N- down

Solution:

$$\Sigma F_x = 3 - 2 = +1 \quad (+x\text{-axis} \rightarrow \text{to right})$$

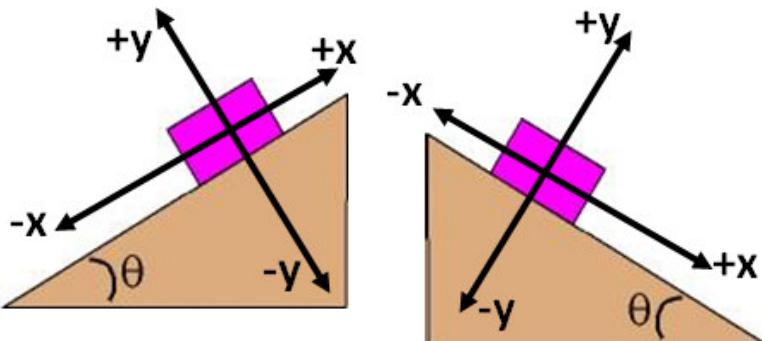
$$\Sigma F_y = 6 - 2 - 4 = 0$$



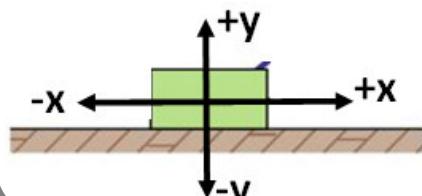
أنواع الأسطح وتمثيل المحاور

السطح المائل (Inclined Plane)

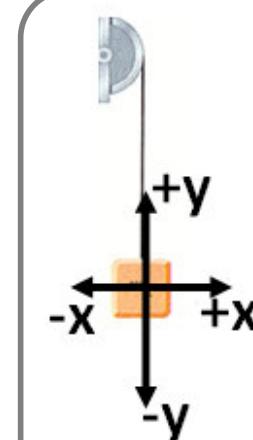
والموازي للسطح الصادي هو في الأسطح المائلة نضع المحور السيني θ العمودي عليه



السطح الأفقي



السطح العمودي

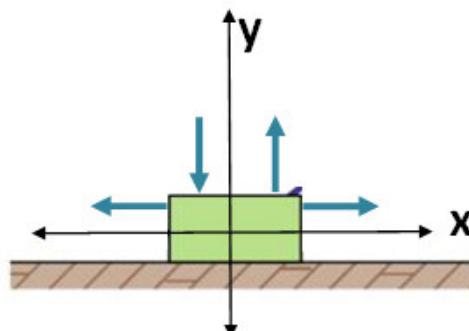


قوة الدفع (الظاهر)

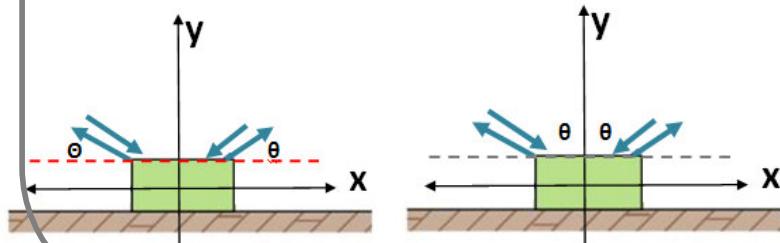
هي القوة التي يؤثر بها مؤثر خارجي على الجسم والتي تسبب حركته، وهي قوة عاديّة نرمز لها بالرمز.. F

السطح الأفقي

موازية للمحاور

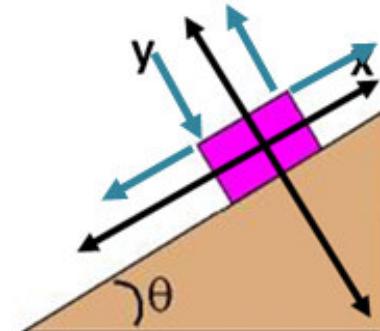


تصنع زاوية مع المحاور

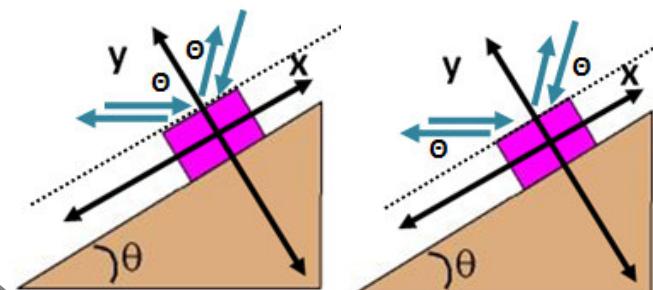


السطح المائل

موازية للمحاور



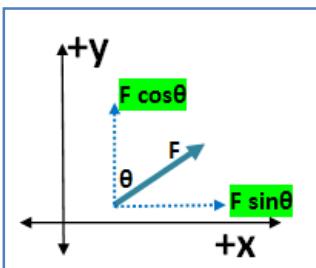
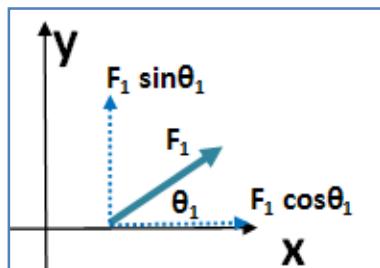
تصنع زاوية مع المحاور



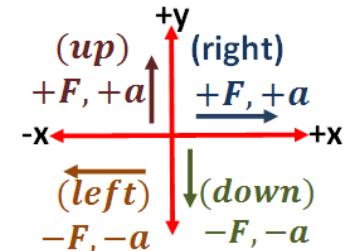
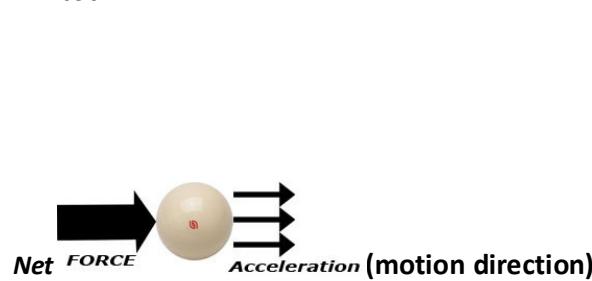
هناه فرhan

ملاحظات عامة:

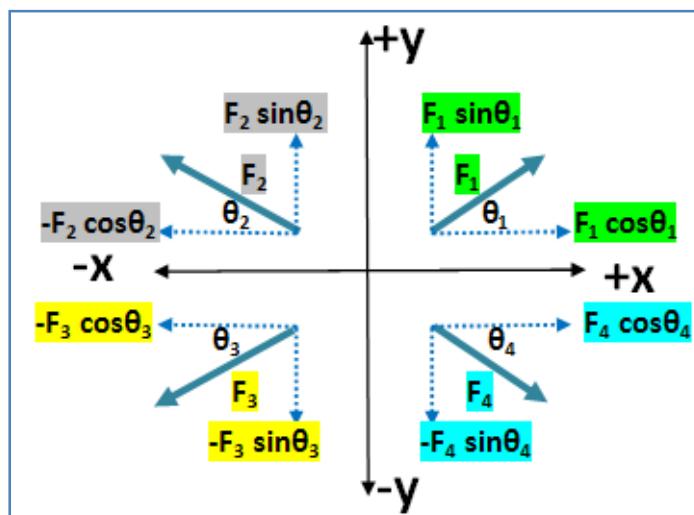
عند تحليل المتجه إلى مركباته فإن المحور المجاور للزاوية يأخذ $(\sin\theta)$ والمحور العمودي يأخذ $-(\cos\theta)$



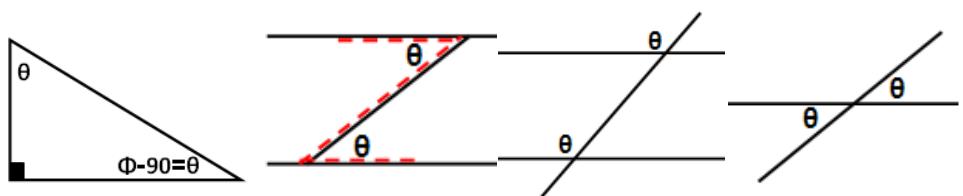
اتجاه الحركة (\vec{F}_{net}) هو اتجاه محصلة القوى



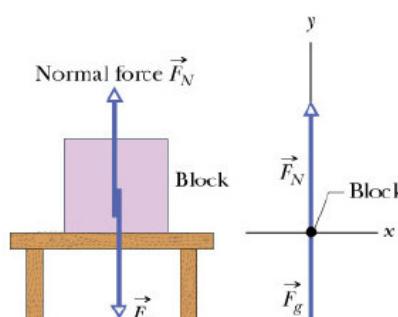
عند تحليل المتجه إلى مركباته يجب أن نأخذ في الاعتبار أشارة المحاور



بعض خصائص الزوايا التي قد تستخدم عند التحليل

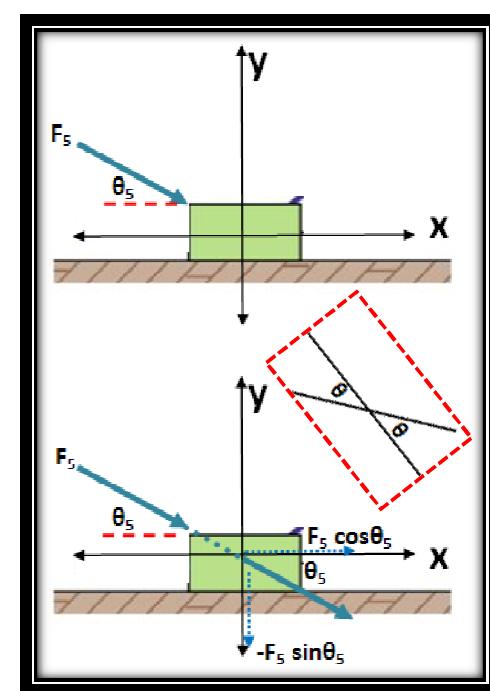
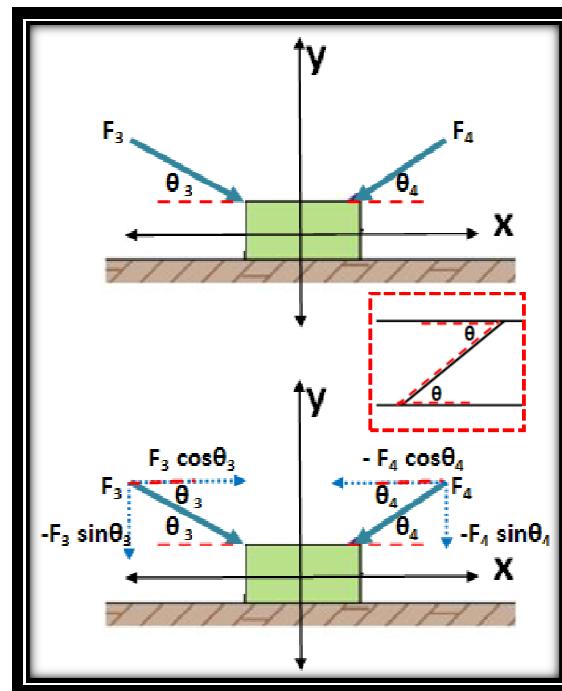
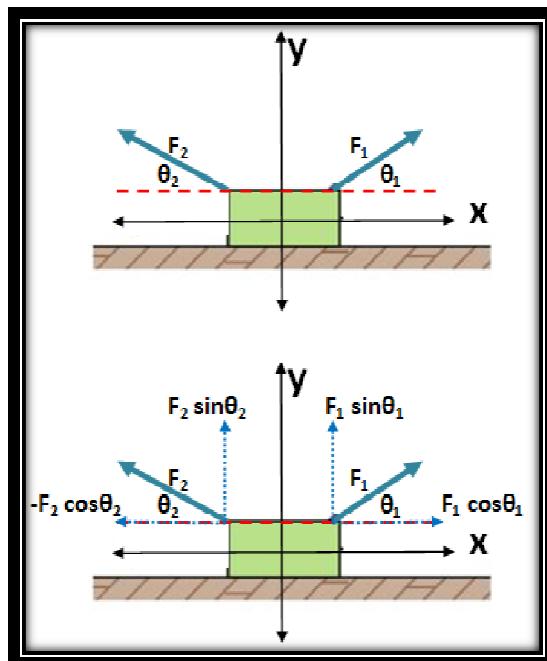


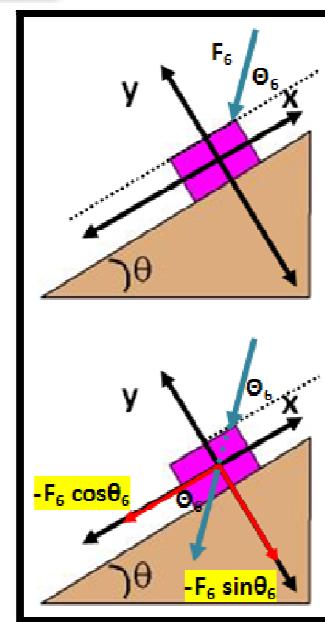
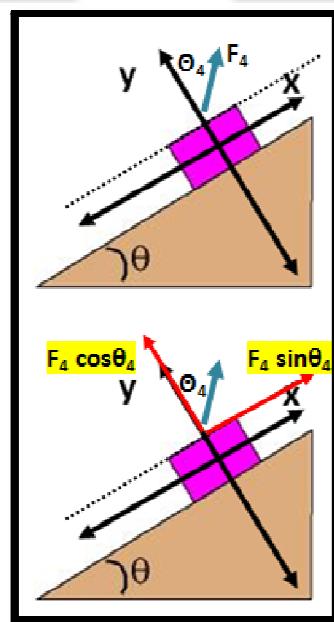
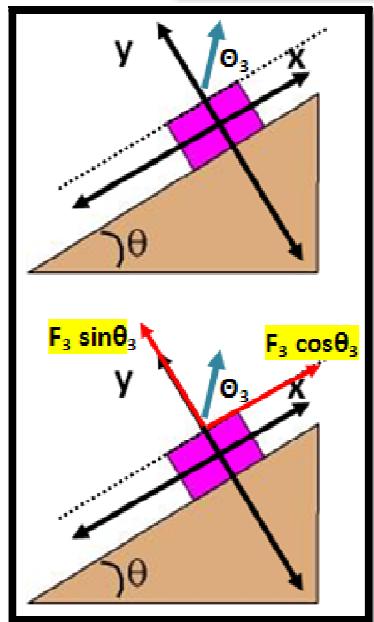
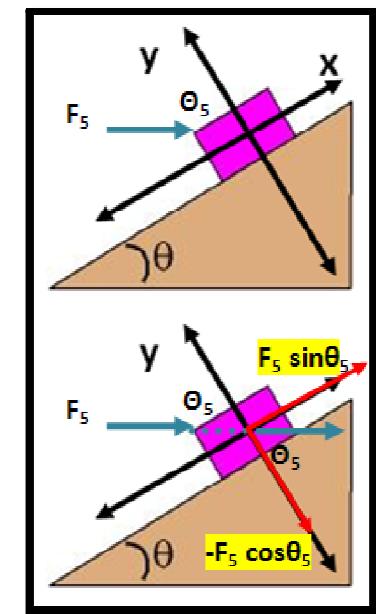
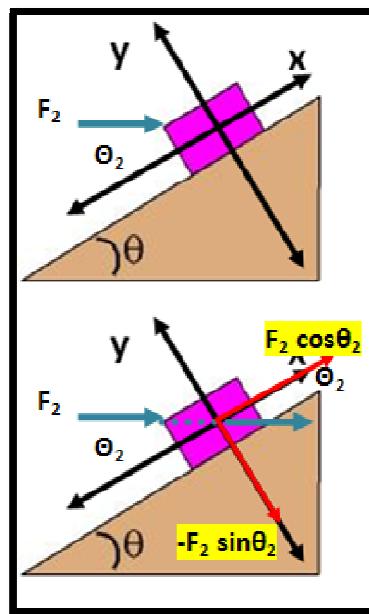
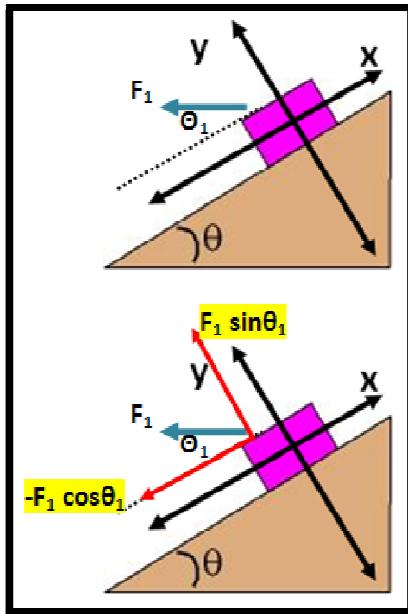
free body diagram هو تبسيط الرسم وذلك برسم المحاور من ثم تحديد الجسم كنقطة في المركز ورسم القوى المؤثرة عليه وفي حالة وجود أكثر من جسم يعامل كل جسم على حدة



Horizontal	أفقي	Hangs	معلق	Sliding	ينزلق
Vertically	عمودي	Elevator	مصعد	Prevent	يمנע
Coefficient	معامل	Rough	خشن	Gravitational	الجاذبية الأرضية
Kinetic	الحركي	smooth	ناعم	Frictional	الاحتكاك
Stationary	ساكن	Stand	يقف	Floor	الارض
Static	السكوني	massless	ليس له وزن	frictionless	عديم الاحتكاك
pulley	بكرة	pull	يسحب	push	يدفع

بعض أمثلة تحليل القوى



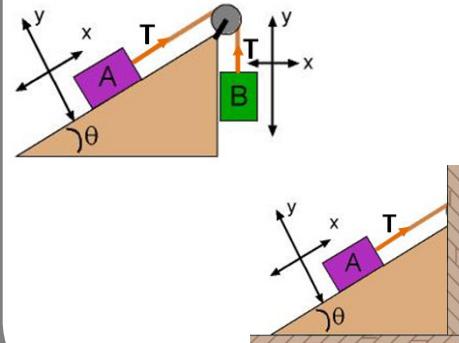
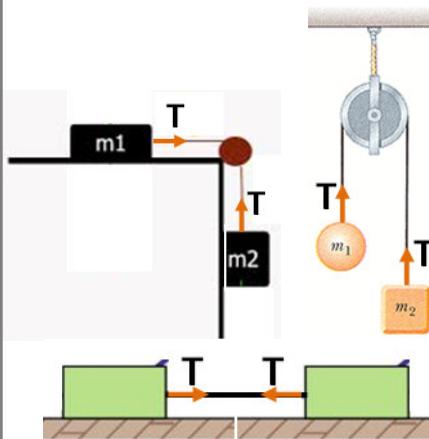


أنواع القوى (الغير ظاهرة)

قوة الشد للحبل (Tension)

* تؤثر دائمًا على الأجسام المربوطة بحبل.
Cord- rope- cable

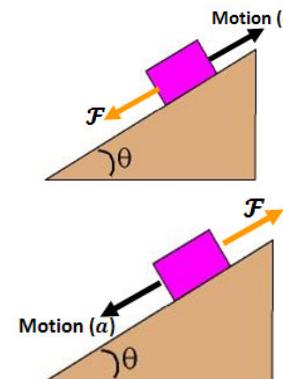
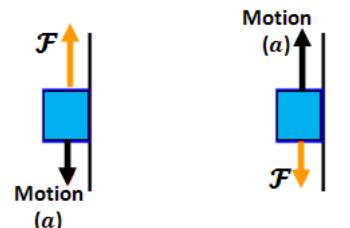
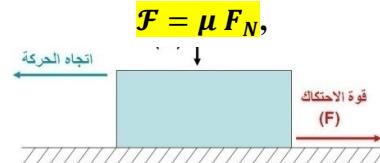
* اتجاهها دائمًا بعيدة عن الجسم
ليس لها مقدار محدد **T**



قوة الاحتكاك (Friction)

* هي القوة ناتجة عن خشونة الأسطح المتركة

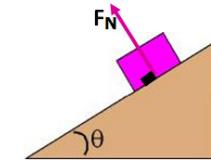
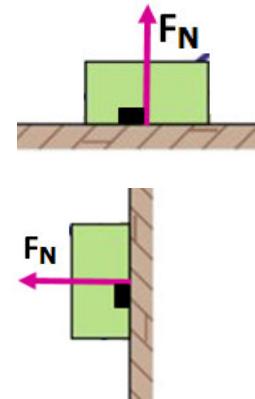
* اتجاهها عكس اتجاه الحركة



القوة العمودية (Normal force)

* تؤثر على الأجسام التي تكون موضوعة على سطح، ولا تؤثر على الأجسام المعلقة.

* اتجاهها عمودية على السطح ولأعلى
ليس لها مقدار محدد **FN**

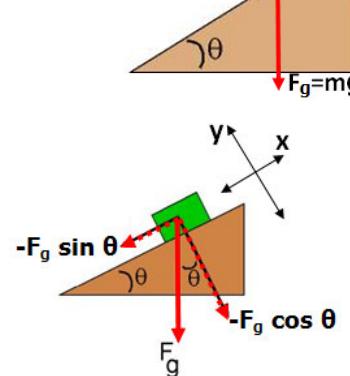
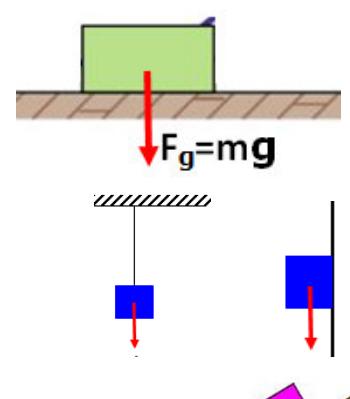


قوة جذب الأرض للأجسام (gravitational force)

* هي القوة الناشئة من جذب الأرض للجسم
وتسمى أيضاً بوزن الجسم

* اتجاهها دائمًا لأسفل

$$F_g = m g$$

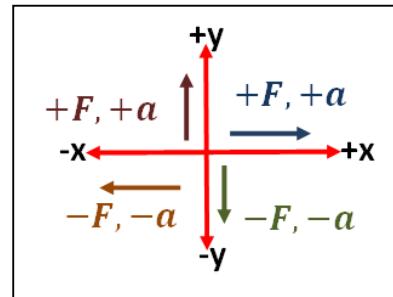


تطبيقات على قوانين نيوتن :

تتبع الخطوات التالية في تطبيقات قوانين نيوتن:

- 1 فهم السؤال جيداً ومن ثم تمثيله برسم إيضاحي.
- 2 معرفة القوى (الظاهرة والغير ظاهرة) التي تؤثر على الأجسام : (1) قوة الجاذبية , (2) قوة رد الفعل,(3) قوة الاحتكاك أو(4) قوة الشد و كذلك (5) قوة الدفع
- 3 رسم (free body diagram) وذلك بتحديد الجسم بنقطة وترسم القوى المؤثرة عليه وفي حالة وجود أكثر من جسم يعامل كل جسم على حدة.
- 4 تحدد محاور الإحداثيات y , x مع تحديد اتجاه أو اتجاهات الحركة.
- 5 تحلل القوى المائلة بحيث تكون جميع القوى إما على المحور السيني أو على الصادي
- 6 يطبق قانون نيوتن الثاني لكل مركبة للفوة والتسارع.

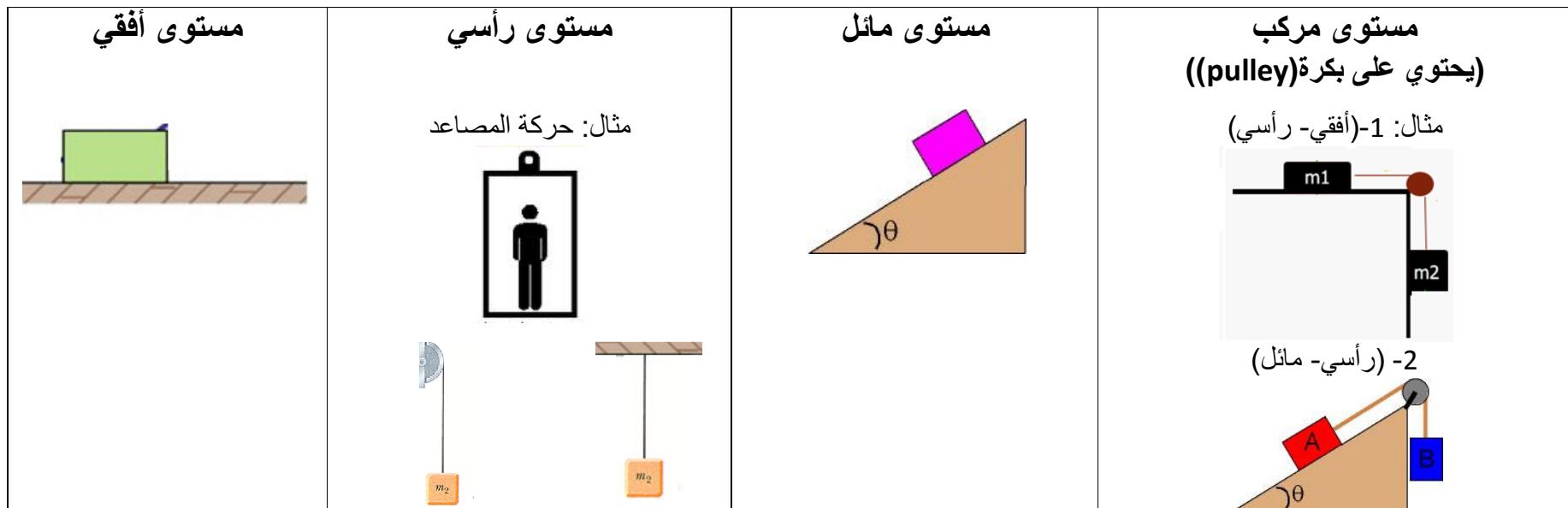
حيث نأخذ القوى المؤثرة في الاتجاه السيني فقط ونطبق عليها نفس الطريقة للاتجاه الصادي



ملاحظة مهمة: أشارة القوى واتجاه الحركة تحدد حسب إشارة المحاور

- 7 حل المعادلات مع بعضها لإيجاد المطلوب في السؤال.

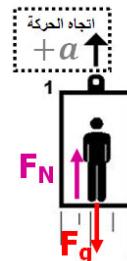
تطبيقات على قوانين نيوتن



Exp. (11):

$$F_N = m(g + a_y) \quad \text{حركة المصاعد}$$

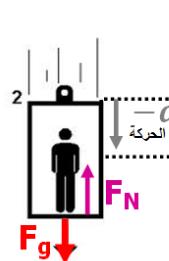
($a_y = +a$) متحرك لأعلى



$$F_N - F_g = ma$$

$$F_N = m(g + a)$$

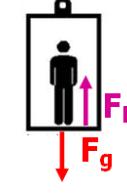
($a_y = -a$) متحرك للأسفل



$$F_N - F_g = -ma$$

$$F_N = m(g - a)$$

ساكن ($a_y = 0$)
 $a = 0$



$$F_N - F_g = 0$$

$$F_N = m g$$

Exp. (12): There are three forces on the 2 kg box shown in the figure. If the box moves with constant acceleration $\vec{a} = 3i - 4j$. Find \vec{F}_3 . (compare solution with Exp. (5))

For x-axis:

$$\sum F_x = m a_x$$

$$F_{1x} + F_{2x} + F_{3x} = m a_x$$

$$20 - 30 \cos(30) + F_{3x} = 2 \times (3)$$

$$F_{3x} = 12 \text{ N}$$

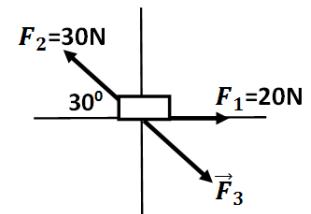
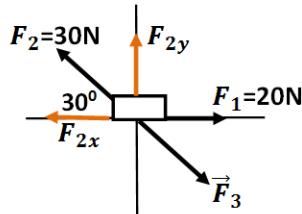
For y-axis:

$$\sum F_y = m a_y$$

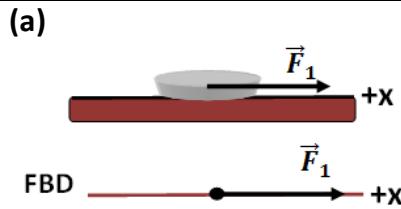
$$F_{1y} + F_{2y} + F_{3y} = m a_y$$

$$0 + 30 \sin(30) + F_{3y} = 2 \times (-4)$$

$$F_{3y} = -23 \text{ N}$$



Exp. (13): Sample problem (5-1) P. 93:

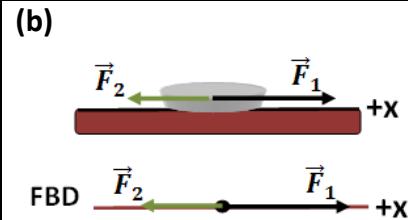


x-axis

$$F_1 = ma_x$$

$$a_x = F_1/m = 4/0.2 = 20 \text{ m/s}^2$$

The force accelerates the puck in the positive direction of the x-axis

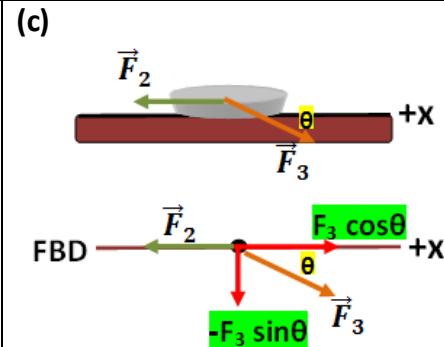


x-axis

$$F_1 - F_2 = ma_x$$

$$a_x = \frac{(F_1 - F_2)}{m} = \frac{4 - 2}{0.2} = 10 \text{ m/s}^2$$

The force accelerates the puck in the positive direction of the x-axis



x-axis

$$+ F_3 \cos(30) - F_2 = ma_x$$

$$a_x = \frac{(F_3 \cos(30) - F_2)}{m} = \frac{1 \cos 30 - 2}{0.2} = -5.7 \text{ m/s}^2$$

The force accelerates the puck in the negative direction of the x-axis

Exp. (14): As shown in the figure (1), a force of 45 N is applied to move a 4 kg box up an inclined plane. If the box starts from rest, find its speed after 2 s. Calculate the normal force, F_N .

Solution:

$$F=45\text{N}, \quad m=4\text{kg}, \quad v_0=0, \quad t=2\text{s} \quad (\text{a}) v=? \quad (\text{b}) F_N=?$$

نحسب السرعة من معالات الحركة

$$v = v_0 + at \rightarrow 1$$

ولإيجاد قيمة التسارع نستخدم قوانين نيوتن للحركة كالتالي:

1- تمثيل القوى الظاهرة (قوة الدفع) والغير ظاهرة (قوة الجذب - القوة العمودية) (كما في الشكل (2))

2- تحديد المحاور واتجاه الحركة

3- حلل القوى المائلة (قوة الجذب) إلى مركباتها (كما في الشكل (3))

4- نكتب معادلات الحركة باستخدام قوانين نيوتن

$$(x\text{-axis}) \rightarrow mg \sin\theta - F = -ma \rightarrow 2$$

$$(y\text{-axis}) \rightarrow F_N - mg \cos\theta = 0 \rightarrow 3$$

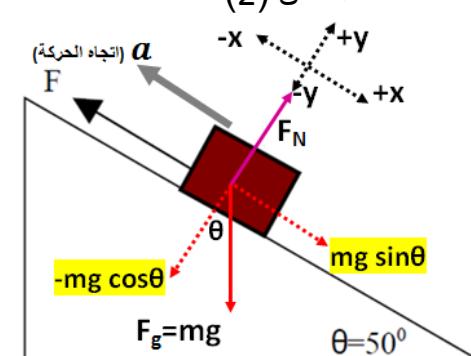
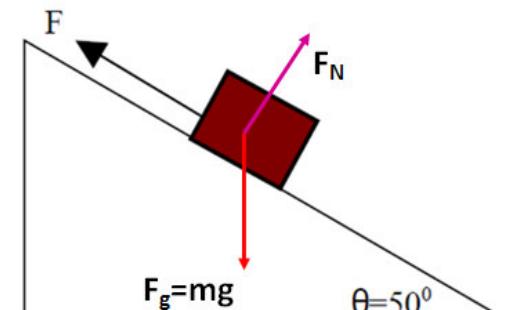
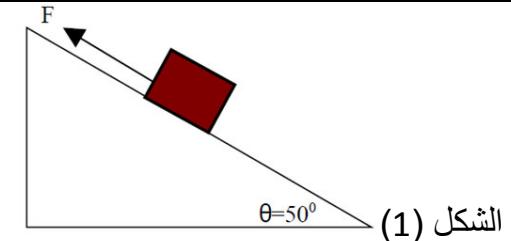
حساب قيمة التسارع من المعادلة الثانية

$$\text{From (2)} \quad 4 \times 9.8 \sin(50^\circ) - 45 = -4 \times a \rightarrow a = 3.74 \text{ m/s}^2$$

التعويض في المعادلة رقم 1 لحساب السرعة

$$v = 3.74 \times 2 = 7.5 \text{ m/s}$$

$$(\text{b}) \text{ from (3)} \quad F_N = mg \cos\theta = 4 \times 9.8 \cos(50^\circ) = 25.2\text{N}$$



Exp. (15): As shown in the figure (1), a force F (makes an angle of 20°) is applied to move a 4 kg box up an inclined plane. If the box moves with constant velocity, find the normal force, F_N .

Solution:

$$F = ??, \quad \phi = 20^\circ, \quad m = 4 \text{ kg}, \quad F_N = ??$$

$$V = \text{constant} \rightarrow a = 0$$

ولإيجاد قيمة القوة العمودية نستخدم قوانين نيوتن للحركة كالتالي:

- 1- تمثيل القوى الظاهرة (قوة الدفع) والغير ظاهرة (قوة الجذب - القوة العمودية) (كما في الشكل (2))
- 2- تحديد المحاور واتجاه الحركة

- 3- حلل القوى المائمه (قوة الجذب - قوة الدفع) إلى مركباتها (كما في الشكل (3))

- 4- نكتب معادلات الحركة باستخدام قانون نيوتن الأول

$$(x\text{-axis}) \rightarrow mg \sin\theta - F \cos\phi = 0 \quad \rightarrow 1$$

$$(y\text{-axis}) \rightarrow F \sin\phi + F_N - mg \cos\theta = 0 \quad \rightarrow 2$$

لحساب قيمة القوة العمودية نحتاج حساب قيمة قوة الدفع وذلك بالتعويض في المعادلة رقم (1)

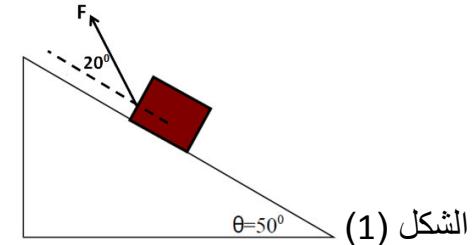
From (1)

$$4 \times 9.8 \times \sin(50^\circ) - F \cos(20^\circ) = 0 \rightarrow F = 32 \text{ N}$$

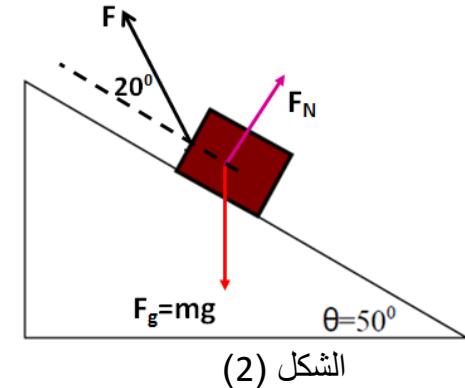
التعويض في المعادلة رقم 2 لحساب القوة العمودية

From (2)

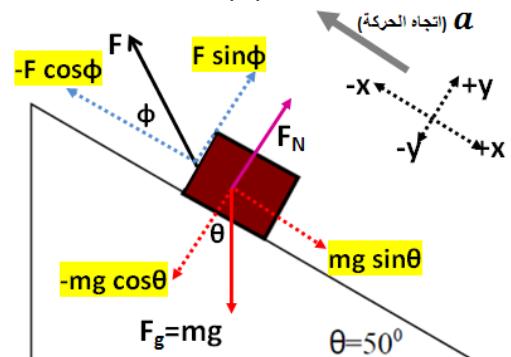
$$32 \times \sin(20^\circ) + F_N - 4 \times 9.8 \times \cos(50^\circ) = 0 \rightarrow F_N = 14.3 \text{ N}$$



الشكل (1)

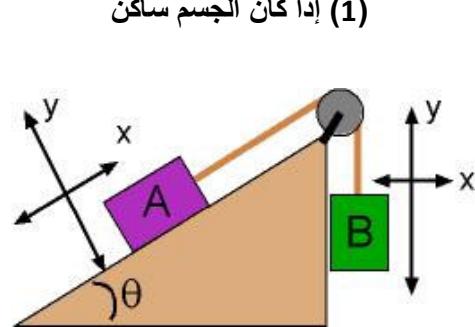
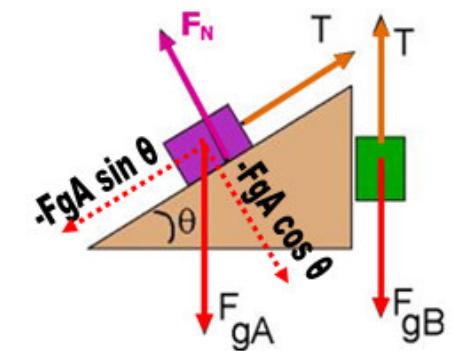
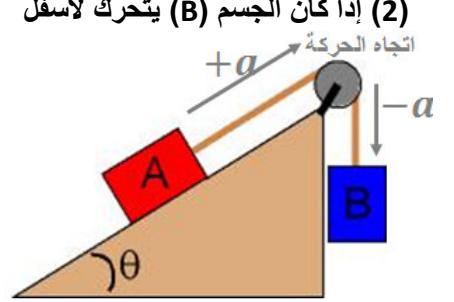
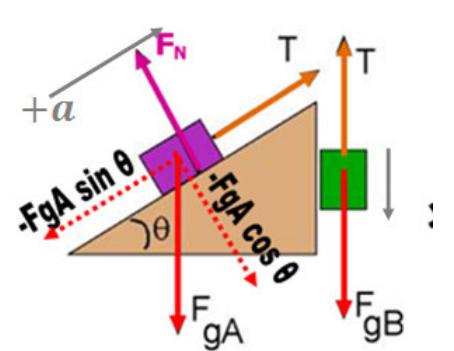
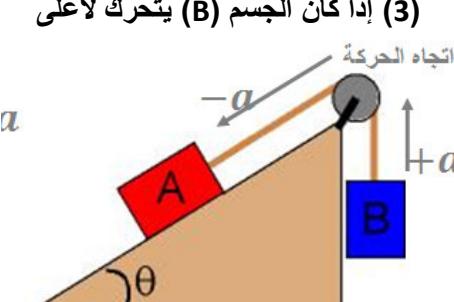
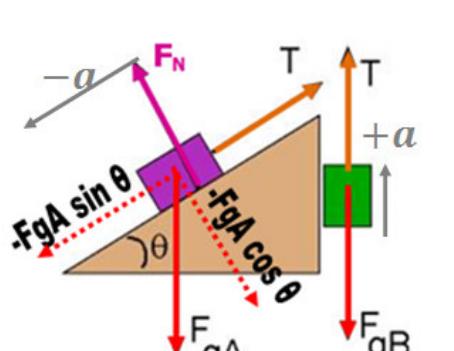


الشكل (2)



الشكل (3)

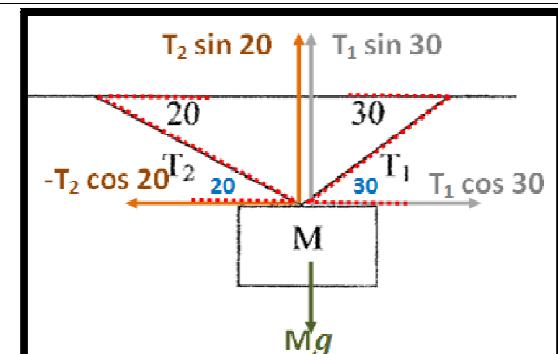
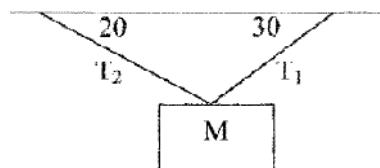
Exp. (16): A block of mass m_A is placed on a frictionless inclined plane. This plane is angled θ degrees above horizontal. The block is connected by an ideal, massless cord and frictionless, massless pulley to a second block of mass m_B which hangs vertically near the end of the inclined plane. Write the motion equations If (1) block A and B are stationary (2) Block B moves down (3) Block B moves up

(1) إذا كان الجسم ساكن	(2) إذا كان الجسم (B) يتحرك لأسفل	(3) إذا كان الجسم (B) يتحرك لأعلى
 	 	 
<p>For m_A: (x-axis) $\rightarrow T - m_A g \sin \theta = 0$</p> <p>(y-axis) $\rightarrow F_N - m_A g \cos \theta = 0$</p> <p>For m_B: (y-axis) $\rightarrow T - m_B g = 0$</p>	<p>For m_A: (x-axis) $\rightarrow T - m_A g \sin \theta = m_A a$</p> <p>(y-axis) $\rightarrow F_N - m_A g \cos \theta = 0$</p> <p>For m_B: (y-axis) $\rightarrow T - m_B g = -m_B a$</p>	<p>For m_A: (x-axis) $\rightarrow T - m_A g \sin \theta = -m_A a$</p> <p>(y-axis) $\rightarrow F_N - m_A g \cos \theta = 0$</p> <p>For m_B: (y-axis) $\rightarrow T - m_B g = +m_B a$</p>

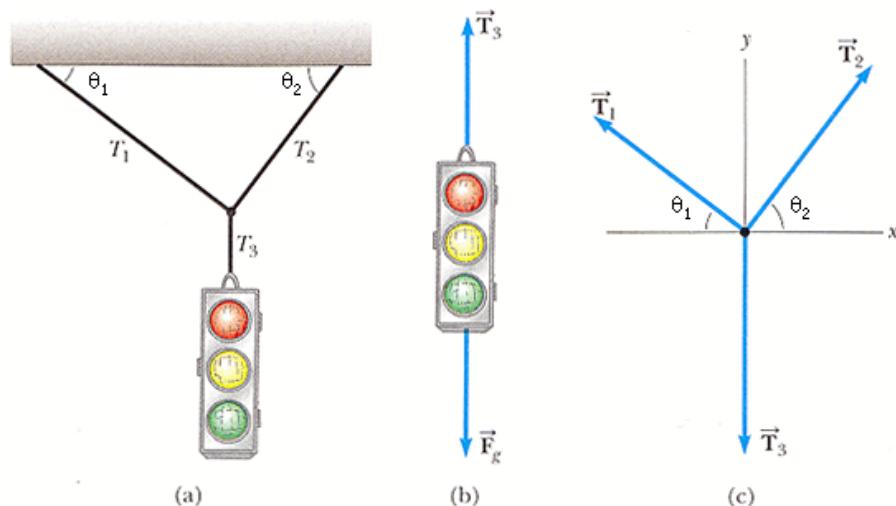
Exp. (17): The mass M of the suspended block in the figure 50kg, and the mass is in equilibrium. What are the tension T_1 and T_2

$$(\text{x-axis}) \rightarrow T_1 \cos 30 - T_2 \cos 20 = 0$$

$$(\text{y-axis}) \rightarrow T_1 \sin 30 + T_2 \sin 20 - Mg = 0$$



Exp. (18): A traffic light weighing 1.00×10^2 N hangs from a vertical cable tied to two other cables that are fastened to a support, as in Figure . The upper cables make angles of $\theta_1 = 39.0^\circ$ and $\theta_2 = 51.0^\circ$ with the horizontal. Find the tension in each of the three cables.

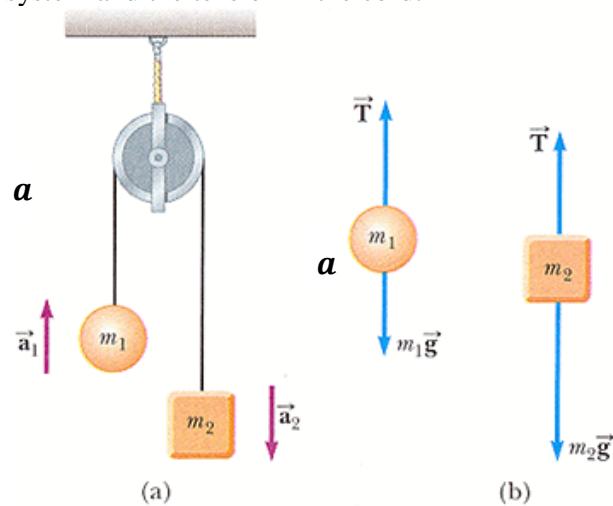


From Fig. (b): $T_3 - F_g = 0$

From Fig. (C): (x-axis) $\rightarrow T_2 \cos \theta_2 - T_1 \cos \theta_1 = 0$

(y-axis) $\rightarrow T_1 \sin \theta_1 + T_2 \sin \theta_2 - T_3 = 0$

Exp. (19): Two objects of mass m_1 and m_2 , with $m_2 > m_1$, are connected by a light, inextensible cord and hung over a frictionless pulley, as in Figure. Both cord and pulley have negligible mass. Find the magnitude of the acceleration of the system and the tension in the cord.

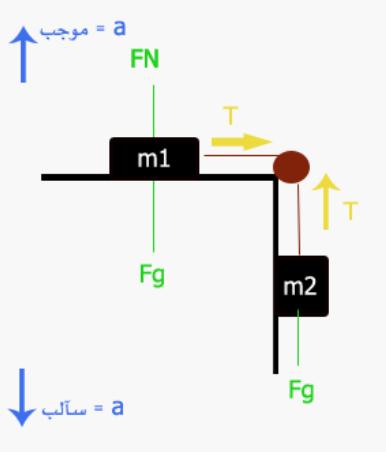
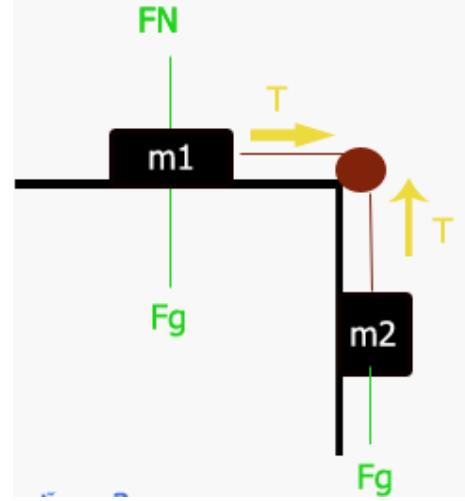
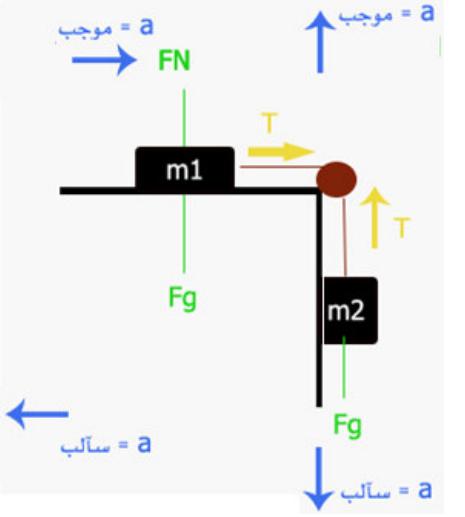


From Fig. (b): (only y-axis)

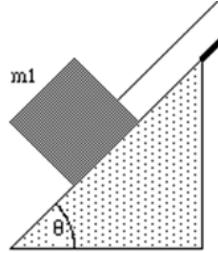
For $m_1 \rightarrow T - m_1 g = +m_1 a$

For $m_2 \rightarrow T - m_2 g = -m_2 a$

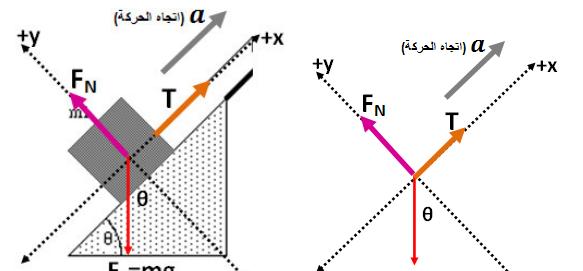
Exp. (20): block of mass m_1 rests on a table and is attached by a string that runs over a frictionless, massless pulley, to a second block of mass m_2 (see figure). The blocks are at rest. What is the tension T in the string?

	إذا كان الجسم الأول ساكن 	إذا كان الجسم الأول يتحرك إلى اليمين والجسم الثاني للأسفل 
$\text{For } m_1: (\text{x-axis}) \rightarrow T = 0$ $(\text{y-axis}) \rightarrow F_N - m_1 g = 0$ $\text{For } m_2: (\text{y-axis}) \rightarrow T - m_2 g = 0$	$\text{For } m_1: (\text{x-axis}) \rightarrow T = +m_1 a$ $(\text{y-axis}) \rightarrow F_N - m_1 g = 0$ $\text{For } m_2: (\text{y-axis}) \rightarrow T - m_2 g = -+m_2 a$	

Exp. (21): Sample problem (5-5) P. 101:



شكل (1)



شكل (2)

لإيجاد قيمة التسارع نستخدم قوانين نيوتن للحركة كالتالي:

1- تمثيل القوى الغير ظاهرة (قوة الجذب- قوة الشد -القوة العمودية)(كما في الشكل

(2)

2- تحديد المحاور واتجاه الحركة

3- حلل القوى المائمه (قوة الجذب) إلى مركباتها (كما في الشكل (3))

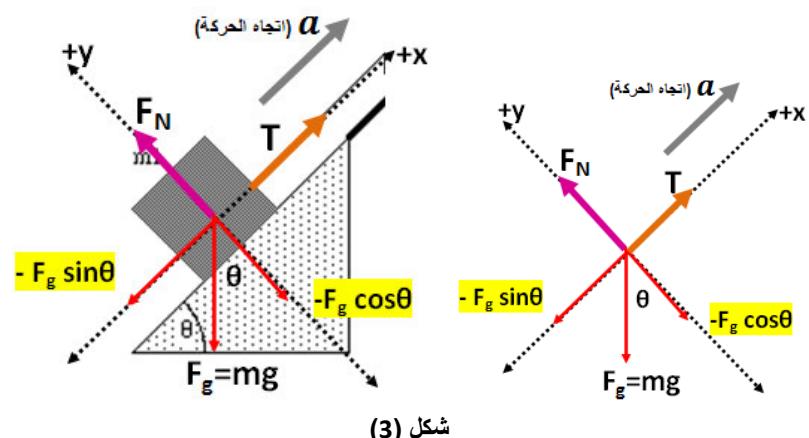
4- نكتب معادلات الحركة بإستخدام قوانين نيوتن

$$(x\text{-axis}) \rightarrow T - mg \sin\theta = ma \quad \rightarrow 2$$

$$(y\text{-axis}) \rightarrow F_N - mg \cos\theta = 0 \quad \rightarrow 3$$

حساب قيمة التسارع من المعادلة الثانية

$$\text{From (2)} \quad 25 - 4 \times 9.8 \sin(30) = 5x a \rightarrow a = 0.1 \text{ m/s}^2$$



شكل (3)

Exp. (22): In the figure two blocks are connected by a rope and pulled on a horizontal table by a force with a magnitude of .20N. If the Mass m =6 kg and M = 8 kg. Find the tension in the rope and the acceleration

$$m=6 \text{ kg}, \quad M=8 \text{ kg}, \quad F=20 \text{ N}, \quad a=? \quad T=?$$

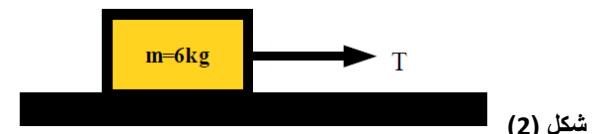
نمثل القوى المؤثرة على الجسمين (كما في الشكل 2-3) على المحور السيني

For m

$$\Sigma F_x = m a_x \rightarrow T = m a \quad (1)$$



شكل (1)



شكل (2)

For M

$$\Sigma F_x = M a_x \rightarrow F - T = M a \quad (2)$$

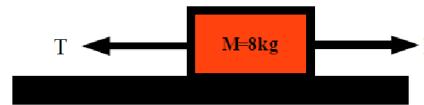
بالتعبير 1 في 2

$$F - m a = M a$$

$$F = (m + M) a \rightarrow a = F/(m + M) = 20/(6+8) = 1.33 \text{ m/s}^2$$

ولإيجاد قيمة الشد نعرض في المعادلة 1

$$T = 6 \times 1.33 = 7.98 \text{ N}$$



شكل (3)

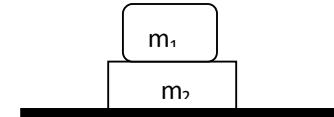
تلاصق الأجسام



$$\begin{aligned} F_{net} &= \sum F = a \sum m \\ &= a (m_1 + m_2) \end{aligned}$$

$$F_{g1} = m_1 g$$

$$F_{g2} = m_2 g$$



When F is applied and two masses move together

$$F_{net} = \sum F = a \sum m$$

$$= a (m_1 + m_2)$$

$$F_{g1} = m_1 g$$

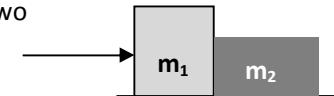
$$F_{g2} = (m_1 + m_2) g$$

Exp. (23): From the figure $m_1=20 \text{ kg}$ and $m_2 = 10 \text{ kg}$. The force acting to accelerate the two bodies by 2 m/s^2 , the force is:

- (a) 60 N (b) 6.0 N (c) 600 N (d) 0.06 N

Solution:

$$F = (m_1 + m_2) a = (20+10) \times (2) = 60 \text{ N}$$



Exp. (24): A constant force of 46 N is applied at an angle of 60° to a block A of a mass 10 Kg as shown in the figure. Block A pushes another block B of mass 36 Kg. (Assume the blocks are on a frictionless surface) the total acceleration of the blocks along the x-axis is.

- (a) 1.5 m/s^2 (b) 0.25 m/s^2 (c) 0.5 m/s^2 (d) 1 m/s^2 (e) 2 m/s^2

Solution:

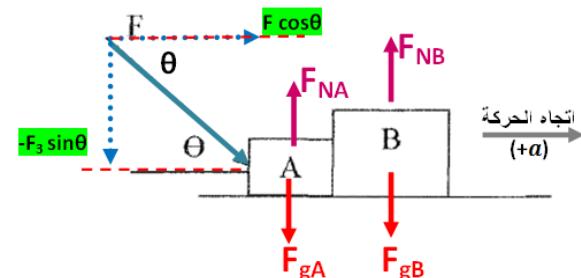
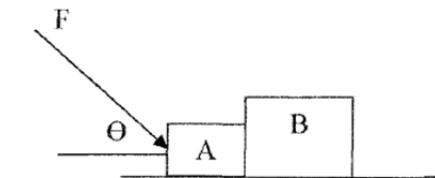
$$m_A = 10 \text{ kg}, \quad m_B = 36 \text{ kg}, \quad \theta = 60^\circ, \quad F = 46 \text{ N}$$

on x-axis:

$$\Sigma F_x = m_a \rightarrow F \cos \theta = a \times (m_A + m_B)$$

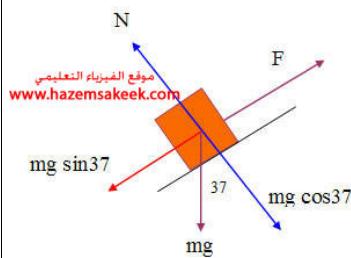
$$a = \frac{F \cos \theta}{m_A + m_B}$$

$$a = \frac{46 \cos 60}{10+36} = 0.5 \text{ m/s}^2$$



Exp. (25): Two blocks having masses of 2 kg and 3 kg are in contact on a fixed smooth inclined plane as in Figure. Calculate the force F that will accelerate the blocks up the incline with acceleration of 2 m/s^2 ,

Solution

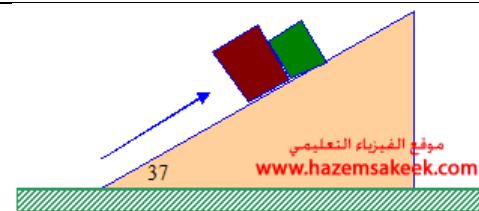


We can replace the two blocks by an equivalent 5 kg block as shown in Figure

the resultant force on the system (the two blocks) in the x direction gives

$$\Sigma F_x = F - mg \sin (37^\circ) = m a_x$$

$$F - 5 (9.8) = 5(2) \rightarrow F = 39.4 \text{ N}$$



Exp. (26): The horizontal surface is frictionless. If $m_1=2\text{kg}$, $m_2=4\text{ kg}$ and $F= 7.8 \text{ N}$,

(1) find the magnitude of the force exerted (المبذولة) by the block m_1 on the block m_2 .

Solution:

أولاً نوجد قيمة التسارع للجسمين وذلك باستخدام قانون نيوتن الثاني

$$F = a \sum m \rightarrow F = (m_1 + m_2) \times a$$

$$7.8 = (2+4) \times a \rightarrow a = 7.8/6 = 1.3 \text{ m/s}^2$$

ثم نوجد قيمة القوى المؤثرة على الجسم 2 (كما في الشكل 3) وذلك بتطبيق قانون نيوتن

$$F_A = F_{21} = m_2 a = 4 \times 1.3 = 5.2 \text{ N}$$

(2) find the magnitude of the force exerted by the m_2 on the block m_1 .

نوجد قيمة القوى المؤثرة على الجسم 1 (كما في الشكل 3) وذلك بتطبيق قانون نيوتن

$$F - F_{12} = m_1 a$$

$$7.8 - F_{21} = 2 \times 1.3$$

$$F_R = F_{12} = 7.8 - 2.6 = 5.2 \text{ N}$$

$$| F_A | = | F_R |$$

Exp. (27): Two boxes $m_1=10\text{ kg}$ and $m_2=15\text{ kg}$,

(1) the gravitational force on m_2 is

Solution:

$$F_{g2} = (m_1 + m_2) g = (10+15) \times 9.8 = 245\text{N}$$

(2) the gravitational force on m_1 is:

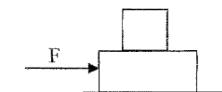
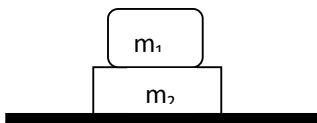
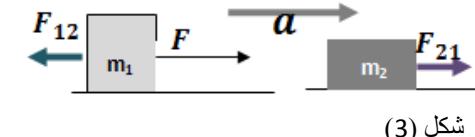
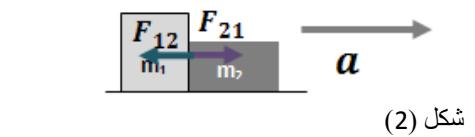
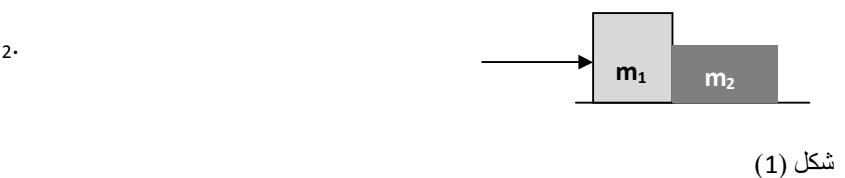
- (a) 0.98 N (b) 9.8 N (c) 98.0 N (d) 98 N

Solution:

$$F_{g1} = m_1 g = 10 \times 9.8 = 98\text{N}$$

(3) The bottom box is pushed with a force F . The two boxes move together with acceleration of 2 m/s^2 , the horizontal force F is

$$m_1 = 10 \text{ kg}, \quad m_2 = 15 \text{ kg}, \quad a = 2 \text{ m/s}^2, \quad F = ???$$



Problems:

1- In SI units a force is numerically equal to the _____, when the force is applied to it.

- A. velocity of the standard kilogram
- B. speed of the standard kilogram
- C. velocity of any object
- D. acceleration of the standard kilogram
- E. acceleration of any object

ans: D

2- A newton is the force:

- A. of gravity on a 1 kg body
- B. of gravity on a 1 g body
- C. that gives a 1g body an acceleration of 1 cm/s^2
- D. that gives a 1 kg body an acceleration of 1 m/s^2
- E. that gives a 1kg body an acceleration of 9.8 m/s^2

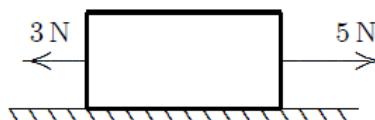
ans: D

3- Mass differs from weight in that:

- A. all objects have weight but some lack mass
- B. weight is a force and mass is not
- C. the mass of an object is always more than its weight
- D. mass can be expressed only in the metric system
- E. there is no difference

ans: B

4- The block shown moves with constant velocity on a horizontal surface. Two of the forces on it are shown. A frictional force exerted by the surface is the only other horizontal force on the block. The frictional force is:



- A. 0
- B. 2 N, leftward
- C. 2 N, rightward
- D. slightly more than 2 N, leftward
- E. slightly less than 2 N, leftward

ans: B

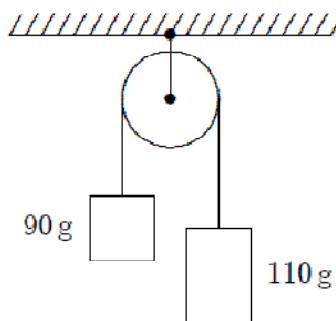
5- A car travels east at constant velocity. The net force on the car is:

- A. east
- B. west
- C. up
- D. down
- E. zero

ans: E

- 6- A constant force of 8.0 N is exerted for 4.0 s on a 16-kg object initially at rest. The change in speed of this object will be:
- A. 0.5 m/s
 - B. 2 m/s
 - C. 4 m/s
 - D. 8 m/s
 - E. 32 m/s
- ans: B
- 7- A 6-kg object is moving south. A net force of 12 N north on it results in the object having an acceleration of:
- A. 2 m/s^2 , north
 - B. 2 m/s^2 , south
 - C. 6 m/s^2 , north
 - D. 18 m/s^2 , north
 - E. 18 m/s^2 , south
- ans: A
- 8- A 25-kg crate is pushed across a frictionless horizontal floor with a force of 20 N, directed 20° below the horizontal. The acceleration of the crate is:
- A. 0.27 m/s^2
 - B. 0.75 m/s^2
 - C. 0.80 m/s^2
 - D. 170 m/s^2
 - E. 470 m/s^2
- ans: B
- 9- A ball with a weight of 1.5 N is thrown at an angle of 30° above the horizontal with an initial speed of 12 m/s. At its highest point, the net force on the ball is:
- A. 9.8 N, 30° below horizontal
 - B. zero
 - C. 9.8 N, up
 - D. 9.8 N, down
 - E. 1.5 N, down
- ans: E
- 10- A 1000-kg elevator is rising and its speed is increasing at 3 m/s^2 . The tension force of the cable on the elevator is:
- A. 6800 N
 - B. 1000 N
 - C. 3000 N
 - D. 9800 N
 - E. 12800 N
- ans: E

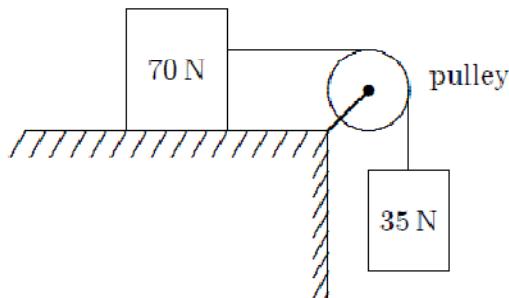
- 11-** When a 25-kg crate is pushed across a frictionless horizontal floor with a force of 200 N, directed 20° below the horizontal, the magnitude of the normal force of the floor on the crate is:
- 25 N
 - 68 N
 - 180 N
 - 250 N
 - 310 N
- ans: E
- 12-** A block slides down a frictionless plane that makes an angle of 30° with the horizontal. The acceleration of the block is:
- 980 cm/s^2
 - 566 cm/s^2
 - 849 cm/s^2
 - zero
 - 490 cm/s^2
- ans: E
- 13-** A 25-N crate slides down a frictionless incline that is 25° above the horizontal. The magnitude of the normal force of the incline on the crate is:
- 11 N
 - 23 N
 - 25 N
 - 100 N
 - 220 N
- ans: B
- 14-** A 25-N crate is held at rest on a frictionless incline by a force that is parallel to the incline. If the incline is 25° above the horizontal the magnitude of the applied force is:
- 4.1 N
 - 4.6 N
 - 8.9 N
 - 11 N
 - 23 N
- ans: D
- 15-** Two blocks are connected by a string and pulley as shown. Assuming that the string and pulley are massless, the magnitude of the acceleration of each block is:



- A. 0.049 m/s^2
- B. 0.020 m/s^2
- C. 0.0098 m/s^2
- D. 0.54 m/s^2
- E. 0.98 m/s^2

ans: E

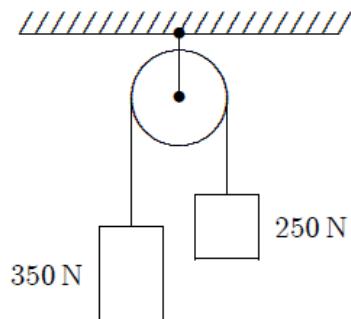
- 16-** A 70-N block and a 35-N block are connected by a string as shown. If the pulley is massless and the surface is frictionless, the magnitude of the acceleration of the 35-N block is:



- A. 1.6 m/s^2
- B. 3.3 m/s^2
- C. 4.9 m/s^2
- D. 6.7 m/s^2
- E. 9.8 m/s^2

ans: B

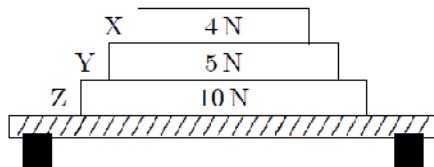
- 17-** Two blocks, weighing 250 N and 350 N, respectively, are connected by a string that passes over a massless pulley as shown. The tension in the string is:



- A. 210 N
- B. 290 N
- C. 410 N
- D. 500 N
- E. 4900 N

ans: B

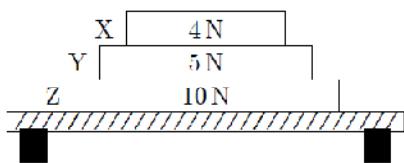
- 18-** Three books (X, Y, and Z) rest on a table. The weight of each book is indicated. The net force acting on book Y is:



- A. 4 N down
- B. 5 N up
- C. 9 N down
- D. zero
- E. none of these

ans: D

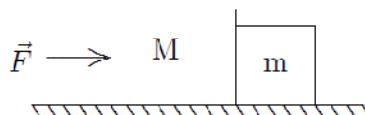
- 19-** Three books (X, Y, and Z) rest on a table. The weight of each book is indicated. The force of book Z on book Y is:



- A. 0
- B. 5 N
- C. 9 N
- D. 14 N
- E. 19 N

ans: C

- 20-** Two blocks with masses m and M are pushed along a horizontal frictionless surface by a horizontal applied force \vec{F} as shown. The magnitude of the force of either of these blocks on the other is:



- A. $mF/(m + M)$
- B. mF/M
- C. $mF/(M - m)$
- D. $MF/(M + m)$
- E. MF/m

ans: A

- 21-** Two blocks (A and B) are in contact on a horizontal frictionless surface. A 36-N constant force is applied to A as shown. The magnitude of the force of A on B is:



- A. 1.5 N
- B. 6.0 N
- C. 29 N
- D. 30 N
- E. 36 N

ans: D

هنساء فرحان