Phys 111 2023

Lecture 15

~~Weds: Group Exercise Credit~~ ~~Warm up 6~~

Weds: Warm up 6

weds: Group Ex

Thurs: Discussion / quiz

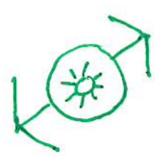
Fri: ~~Group Ex~~

Ex 130, 131, 132, 137, 139, 142

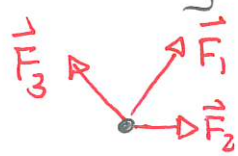
Newton's Second Law

The scheme for Newton's Second Law is

Identify object of interest. Mass m



→ List all forces on the object using a free-body diagram



→ Net force

$$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \dots$$
$$= \sum_i \vec{F}_i$$

→ The acceleration of the object is given indirectly by

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

Practically speaking this requires us to add vectors. This requires components. Thus there are some implicit steps.

Get all components of all forces

	x	y
$\vec{F}_1$	F_{1x}	F_{1y}
$\vec{F}_2$	F_{2x}	F_{2y}
⋮	⋮	⋮

→

$$F_{net\,x} = F_{1x} + F_{2x} + F_{3x} + \dots = \sum F_{ix}$$
$$F_{net\,y} = F_{1y} + F_{2y} + F_{3y} + \dots = \sum F_{iy}$$

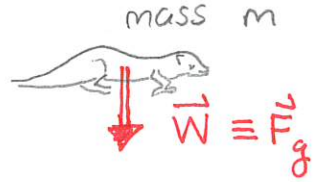
→

$$F_{1x} + F_{2x} + \dots = m a_x$$
$$F_{1y} + F_{2y} + \dots = m a_y$$

Weight (Gravitational Force)

Earth always exerts a gravitational force on any object near to its surface. This gravitational force is sometimes called the weight. The rules for determining this are

> The gravitational force exerted by Earth on a nearby object (also called weight $\vec{W}$) has:
>
> a) direction toward center of Earth
>
> b) magnitude
>
> $$W = mg \quad \text{or} \quad F_g = mg$$



We can apply this rule to an object in free fall

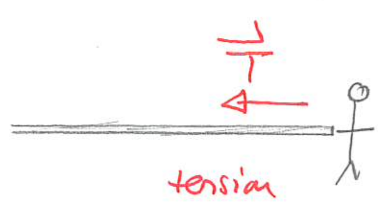
$$\sum F_{ix} = ma_x \Rightarrow \cancel{W_x}^{0} = ma_x \Rightarrow ma_x = 0 \Rightarrow a_x = 0$$

$$\sum F_{iy} = ma_y \Rightarrow W_y = ma_y \Rightarrow -mg = ma_y \Rightarrow a_y = -g$$

This correctly predicts free-fall acceleration.

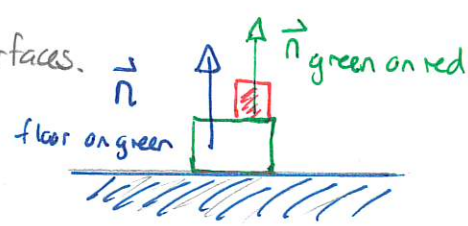
Tension

Stretched ropes, cables, chains can exert forces. These point in the direction of pull.



Normal force

Normal forces result from interactions between surfaces.



> When two objects are in contact, each exerts a normal force on the other. The normal force has:
>
> a) direction perpendicular to the surface
>
> b) adjustable magnitude.

Quiz 1 60% – 90%

Quiz 2 70% – 90%

DEMO: Scale / mass –

Equilibrium

An equilibrium situation is one where the acceleration is zero. These occur when:

1) the object is at rest
2) the object moves with constant velocity.

In these cases.

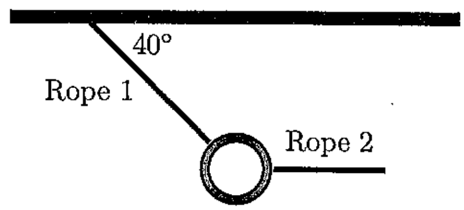
$$\vec{a} = 0 \Rightarrow \vec{F}_{net} = 0$$

$$\Rightarrow \boxed{\begin{array}{l} \sum F_{ix} = 0 \\ \sum F_{iy} = 0 \end{array}}$$

Equilibrium!

127 Suspended ring in equilibrium, 1

A 2.50 kg ring is suspended from the ceiling and is held at rest by two ropes as illustrated. Rope 2 pulls horizontally. The aim of this exercise is to use Newton's 2nd Law to determine the tension in each rope. One piece of background information that you will need to answer this is that the magnitude of the gravitational force on an object of mass m is $w = mg$. *(111F2023)*



a) Draw a free body diagram for the ring. Label the tension forces $\vec{\mathbf{T}}_1$ and $\vec{\mathbf{T}}_2$.

b) Write Newton's 2nd Law in its component form, i.e. write

$$F_{\text{net } x} = \Sigma F_{ix} = m a_x \quad (1)$$
$$F_{\text{net } y} = \Sigma F_{iy} = m a_y \quad (2)$$

Insert as much information as possible about the acceleration. You will return to these equations shortly; they will generate the algebra that eventually gives you the tensions.

c) These equations require all components of all forces, including the two unknown tension forces. In order to manage these, you should express the components of each tension force in terms of its magnitude. When doing this denote the magnitude of the tension in rope 1 by T_1 and for rope 2, by T_2.

d) List as much information as possible about each component for each force; each could be a number or an algebraic expression. Use one of the two formats below.

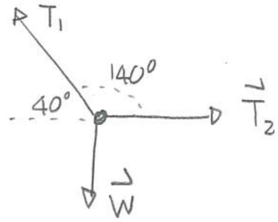
$$w_x = \cdots$$
$$w_y = \cdots$$
$$T_{1x} = \cdots$$
$$T_{1y} = \cdots$$
$$\vdots$$

Force	x comp	y comp
$\vec{\mathbf{w}}$		
$\vec{\mathbf{T}}_1$		
$\vdots$		

e) Use Eq. (1) to obtain an equation relating various quantities that appear in this problem. Do the same with Eq. (2). You should get two expressions that contain the two unknowns T_1 and T_2. Solve them for the unknowns.

f) If you had one rope that is rated to break when the tension exceeds 30 N and another rated to break when the tension exceeds 40 N, which one would you use to suspend the object as illustrated above?

Answer: a)



b) $\sum F_{ix} = ma_x = 0$

$\sum F_{iy} = ma_y = 0$

$\Rightarrow \sum F_{ix} = 0$ → says - find all x components
- add them
- set = 0
- do algebra

$\sum F_{iy} = 0$

c) $T_{1x} = T_1 \cos 140^\circ = T_1(-0.766)$

$T_{1y} = T_1 \sin 140^\circ = T_1(0.643)$

$T_{2x} = T_2$

$T_{2y} = 0$

d) →

	x comp	y comp
$\vec{W}$	0	−24.5 N
$\vec{T}_1$	$-0.766\,T_1$	$0.643\,T_1$
$\vec{T}_2$	T_2	0 N

e) $\sum F_{ix} = 0$ means $0 - 0.766T_1 + T_2 = 0$

$\sum F_{iy} = 0$ means $-24.5\text{N} + 0.643T_1 = 0$

Solve first for T_1 then substitute and solve for T_2

$0.643T_1 = 24.5\text{N}$

$T_1 = \dfrac{24.5\text{N}}{0.643} \Rightarrow \boxed{T_1 = 38.1\text{N}}$

Now $-0.766\,T_1 + T_2 = 0$

$\Rightarrow -0.766 \times 38.1\text{N} + T_2 = 0 \Rightarrow -29.2\text{N} + T_2 = 0$

$\Rightarrow \boxed{T_2 = 29.2\text{N}}$

f) 30N rope horizontal
40N rope angled