Tues: Discussion/quiz

~~130, 140, 144,~~ 152, 139, 140, 144, 149, 152, 153, 160, 164

Thurs: Group exercise

Newton's Second Law

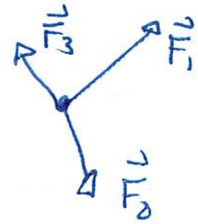
Newton's second law gives a framework for assessing the effects of forces

Object mass m

Identify forces

→

Create a free-body diagram



* one vector for each force

→

Find acceleration via

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

$\Rightarrow \sum \vec{F}_i = m\vec{a}$

$\Rightarrow F_{1x} + F_{2x} + \ldots = ma_x = \sum F_{ix}$

$F_{1y} + F_{2y} + \ldots = ma_y = \sum F_{iy}$

→

Insert as much information as possible about the acceleration

→

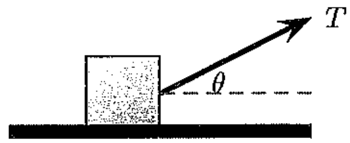
Algebra will give remaining unknowns, e.g.
* acceleration
* forces

Newton's Second Law in component form.

Warm Up 1

157 Rope pulling a box

A 45.0 kg box can move along a frictionless horizontal surface. A rope pulls on the box with tension T at angle θ. *(131Sp2025)*



a) Do you expect that the normal force exerted by the floor depends on the tension and angle of rope pull?

b) Draw a free body diagram for the box.

c) Write Newton's Second Law in its component form and insert as much information as possible about the components of acceleration at this stage. These equations will generate the algebra that eventually gives you the acceleration and the normal force.

d) List all the components of all the forces.

e) Use Newton's second law in component form to relate the acceleration components to the force components.

f) Determine an expression for the acceleration of the box.

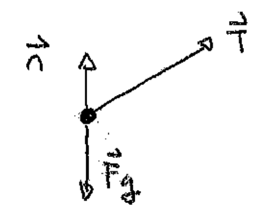
g) Determine an expression for the normal force on the box. Does the expression support your expectations about how normal force depends on the tension and the angle of pull?

h) Determine the acceleration and normal force when the rope pulls horizontally with force 275 N.

i) Determine the acceleration and normal force when the rope pulls midway between horizontally and vertically 275 N.

Answer: a) —

b)

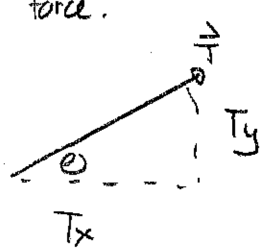


c) $\sum F_{ix} = ma_x$

$\sum F_{iy} = ma_y$ and $a_y = 0$ since there is no vertical motion.

d) $F_g = mg$

let n be the magnitude of the normal force.



$T_x = T\cos\theta$

$T_y = T\sin\theta$

	x comp	y - comp
$\vec{F}_g$	0	$-mg$
$\vec{n}$	0	n
$\vec{T}$	$T\cos\theta$	$T\sin\theta$

e) $\sum F_{ix} = Ma_x \Rightarrow \boxed{T\cos\theta = m a_x}$ -(1)

$\sum F_{iy} = Ma_y \Rightarrow \boxed{-mg + n + T\sin\theta = 0}$ -(2)

f) Using (1) $a_x = \dfrac{T\cos\theta}{m}$ -(3)

g) Using (2) $n = mg - T\sin\theta$ -(4)

As θ increases, $\sin\theta$ increases $\Rightarrow$ n decreases

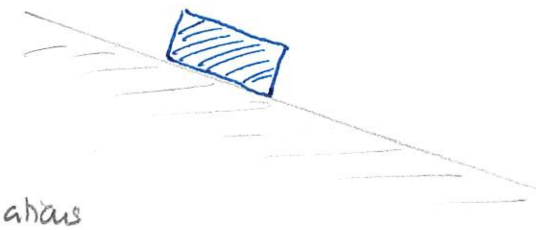
h) Here $\theta = 0$ $\Rightarrow$ $a_x = \dfrac{275N\cos 0^\circ}{45kg} \Rightarrow a_x = 6.1 m/s^2$

$n = 45kg \times 9.8 m/s^2$ ~~$- 275N \sin 0^\circ$~~ $\Rightarrow n = 441N$

i) Here $\theta = 45^\circ$ $\Rightarrow$ $a_x = \dfrac{275N\cos 45^\circ}{45kg} = 4.3 m/s^2$

$n = 45kg \times 9.8 m/s^2 - 275N \sin 45^\circ \Rightarrow n = 247N$

Object on a ramp



One of the original physics problems, first analyzed by Galileo in the early 1600s, concerns an object sliding down an inclined ramp. Galileo's investigations showed that the acceleration is constant.

We also encounter such motion:

* skiers and sledders on slopes — Bobsled video
* vehicles sliding up and down inclines.

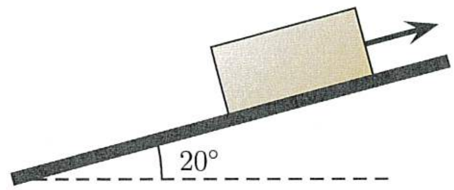
Quiz 1 70% — 90%

Quiz 2 80% — 90%

Quiz 3 80% — 90%

179 Crate dragged up a ramp

A crate, with mass m, can move along a frictionless ramp angled 20° from the horizontal. A rope is attached to the crate and it pulls parallel to the ramp and upward with a tension T. *(131F2024)*



a) Draw a free body diagram for the box.

b) Describe the x and y axes that you will use.

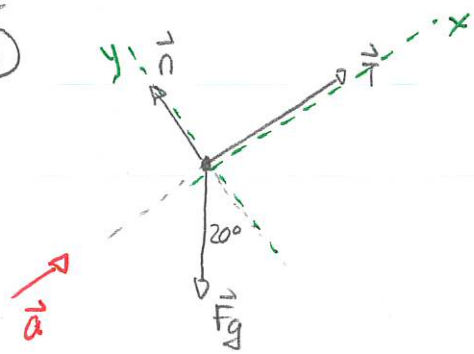
c) Use the system of Newton's Second Law (i.e. component version of the law, acceleration and force components) to determine an expression for the acceleration of the crate.

d) Consider a crate with mass 15 kg and a rope pulling with tension 75 N. Is it possible to say with certainty whether the crate is moving up the ramp or down the ramp? Is either direction possible in this situation? If only one direction is possible, which is it?

e) Suppose that the crate is initially at rest. How long will it take for it to slide 1.5 m along the ramp?

Answers: a

①

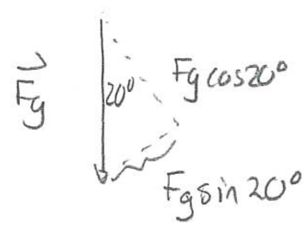


b) ② Tilt the axes with x axis along the acceleration

c) ③ $\sum F_{ix} = ma_x$

$\sum F_{iy} = ma_y = 0$ doesn't leave ramp

④ Components



$F_g = mg$

tilted!!

	x	y
$\vec{F_g}$	$-mg\sin 20°$	$-mg\cos 20°$
$\vec{n}$	0	n
$\vec{T}$	T	0

(5) $\sum F_{ix} = ma_x \Rightarrow -mg\sin 20° + T = ma_x$

$$\Rightarrow \frac{T - mg\sin 20°}{m} = a_x$$

d) Hoe $a_x = \frac{75N - 15kg \times 9.8m/s^2 \sin 20°}{15kg} = \frac{24.7N}{15kg} \Rightarrow a_x = 1.6m/s^2$

) It could be moving up and speeding up

It could be moving down and slowing.

e)

$t_i = 0s$ $t_f = ?$

$X_i = 0m$ $X_f = 1.5M$

$V_{ix} = 0m/s$ $V_{fx} = ?$

$a_x = 1.6m/s^2$

$X_f = \cancel{X_i} + \cancel{V_{ix}\Delta t} + \frac{1}{2} a_x \Delta t^2$

$1.5m = \frac{1}{2}(1.6m/s^2)\Delta t^2$

$\Delta t^2 = 1.82s^2$

$\Rightarrow \Delta t = 1.35s$