Phys 131 2023

Lecture 16

Thurs: Discussion / quiz

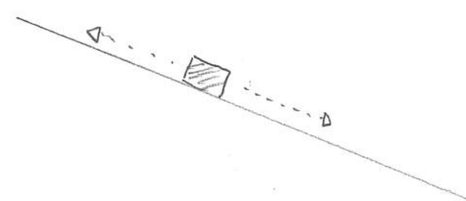
Ex 105, 107, 109, 112
113, 122, 124, 127

Packet updated Friday, Feb 24

Thurs: Seminar WS 203 12:30 - 1:30pm

Newton's Second Law: Object on a Ramp

Objects will frequently move along inclined, non-horizontal surfaces. The framework of Newton's Second Law allows us to address their motion



DEMO: PhET ~~Forces & Mot~~ Ramp: Forces + Motion
Settings: Ice
No vectors

Push + Release

Examples include:
* Skier / Sledder on a flat inclined surface
* Vehicles moving up/down inclines.

The same frame work applies

Identify forces (FBD) → List components → Insert into
$\Sigma F_{ix} = ma_x$
$\Sigma F_{iy} = ma_y$

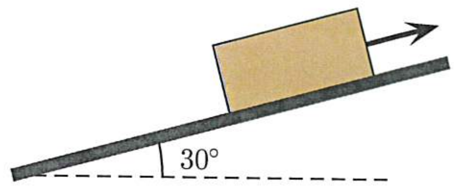
Warm Up 1

Quiz 2

DEMO: PhET Ramp: Show forces...

133 Object pulled along a ramp

A 4.0 kg box can move along a frictionless ramp angled 30° from the horizontal. A person pulls on a rope which exerts a force of 15 N up the ramp parallel to its surface. The object of this exercise is to determine the acceleration of the box. *(131Sp2023)*



a) Draw a free body diagram for the box.

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

c) Write Newton's Second Law in vector form and also in its component form, i.e. write

$$F_{\text{net } x} = \Sigma F_x = \cdots \tag{7}$$
$$F_{\text{net } y} = \Sigma F_y = \cdots \tag{8}$$

Insert as much information as possible about the components of acceleration at this stage. The resulting equations will generate much of the algebra that follows.

d) Determine the magnitude of the gravitational force.

e) List all the components of all the forces, using one of the two formats below.

$$F_{gx} = \cdots$$
$$F_{gy} = \cdots$$
$$n_x = \cdots$$
$$n_y = \cdots$$
$$\vdots$$

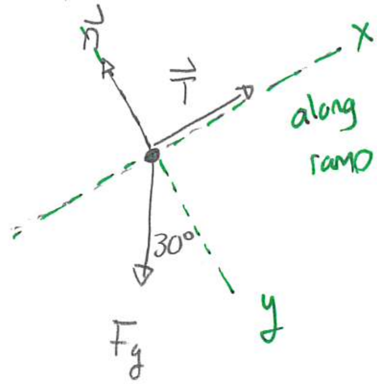
Force	x comp	y comp
$\vec{\mathbf{F}}_g$		
$\vec{\mathbf{n}}$		
$\vdots$		

f) Use Eq. (7) to obtain an equation relating various quantities that appear in this problem. Do the same with Eq. (8).Use the resulting equations to determine the acceleration of the box.

g) Is it possible to say with certainty whether the box 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?

h) Suppose that the box is initially at rest. With the indicated applied force, how long will it take for the box to slide a distance of 2.0 m along the ramp?

Answers: a)



b) tilt axes as illustrated

c) $F_{net\,x} = ma_x \Rightarrow \sum F_{ix} = ma_x$

$F_{net\,y} = ma_y \Rightarrow \sum F_{iy} = ma_y = 0$ since object does not off the ramp (ie. is fixed at $y=0$)

d) $F_g = mg = 4.0 \times 9.8\,m/s^2 = 39N$

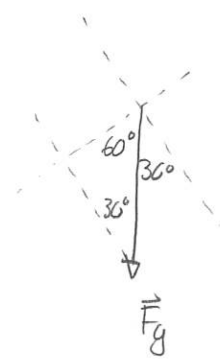
e) Use the tilted axis for co-ordinates:

$\vec{n}$ only along y $\Rightarrow$ $n_x = 0$, $n_y = n$

$\vec{T}$ only along x $\Rightarrow$ $T_x = T = 15N$, $T_y = 0$

	x	y
$\vec{F}_g$	−19.5 N	−34 N
$\vec{n}$	0	n
$\vec{T}$	15 N	0

$\vec{F}_g$ has components along both



$F_{gx} = -F_g \sin 30° = -39N \sin 30°$
$= -19.5N$

$F_{gy} = -F_g \cos 30° = -39N \cos 30°$
$= -34N$

f) $\sum F_x = ma_x \Rightarrow -19.5N + 15N = 4.0kg\; a$

$\Rightarrow -4.5N = 4.0\,kg\; a$

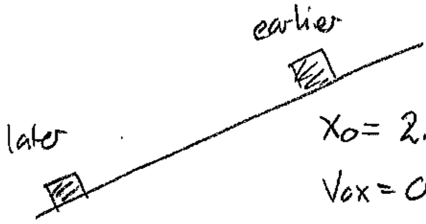
$\Rightarrow a = -\dfrac{4.5N}{4.0kg} = -1.13\,m/s^2$

$\sum F_{iy} = ma_y = 0 \Rightarrow -34N + n = 0 \Rightarrow n = 34N.$

g) No - it could ascend while slowing

- it could descend while speeding up.

f)



$X_0 = 2.0m$

$V_{0x} = 0m/s$

$t_0 = 0s$

$X = 0.0m$

$V_x = ?$

$t = ?$

$X = X_0 + \cancel{V_{0x}} t + \frac{1}{2} a_x t^2$

$0m = 2.0m + \frac{1}{2}(-1.125m/s^2) t^2$

$\Rightarrow -2.0m = -\frac{1}{2} \times 1.125m/s^2 \; t^2$

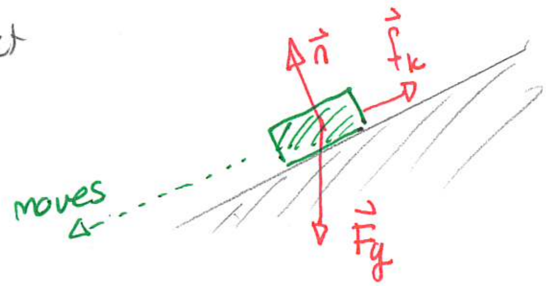
$\Rightarrow 3.56 \; s^2 = t^2$

$\Rightarrow t = \sqrt{3.56s^2} = 1.89s$

Friction

In general a surface can exert a normal force perpendicular to the surface. It can also exert a friction force parallel to the surface. There are two main types of friction.

1) Kinetic friction : occurs when the object moves relative to the surface.
This is denoted $\vec{f}_k$ and has



* direction opposite to motion

* magnitude

$$f_k = \mu_k n$$

where μ_k = coefficient of kinetic friction

n = magnitude of normal force

Quiz 1 20% – 60% & 30% – 60%

Warm Up2

2) static friction : occurs when the object is at rest and would otherwise accelerate in the absence of friction. This is denoted $\vec{f}_s$ and has

* direction : opposite to motion that would occur in its absence

* magnitude : adjusts to the circumstances but has a maximum of

$$f_{s\,max} = \mu_s n$$

where μ_s is the coefficient of static friction. that depends on the two surfaces