Lecture 17

Mon: HW by 5pm

Ex: 144, 145, 146, 151, 152, 153, 158, 159

Weds: Warm Up 7 (DZL)

Dynamics of an object on a slope

We could investigate forces and accelerations for freely falling objects. One challenge is that, for ordinary objects and distances, the motion is too rapid to analyze easily. An alternative, devised by Galileo, is to have an object slide down an inclined slope

Demo: Track + cart – made to do ramp motion

The basic framework is the same:

1. Draw FBD
2. Write Newton's Second Law

$$\Sigma F_{ix} = ma_x \quad \leftarrow \text{insert as much info about accel now}$$
$$\Sigma F_{iy} = ma_y$$

3. Evaluate magnitudes of any forces possible
4. List all components

	x	y
$\vec{F}_1$	...	...
$\vec{F}_2$	...	...

5. Insert components into Newton's Second Law - algebra does the rest

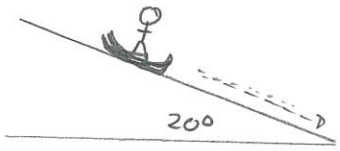
147 Sledding down a slope

A sled and person, with combined mass 100 kg slide down a flat frictionless surface that is angled at 20° above the horizontal. *(111F2023)*

a) Determine the acceleration of the sled and person.

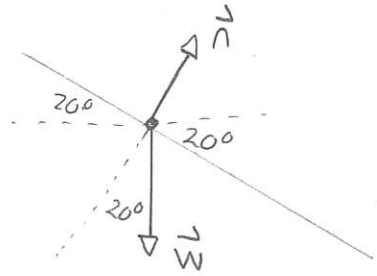
b) Determine the normal force on the sled and person.

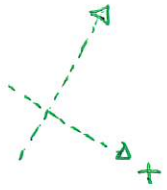
Answer:



Quiz 1 10% – 20%

(1) FBD





Tilted Axes

(2) Newton's Second Law.

$$\Sigma F_{ix} = ma_x$$

$$\Sigma F_{iy} = ma_y$$

With the usual axes we have to include information that the sled stays on the slope. We can however use tilted axes that automatically insets this. One of the axes lies along the slope. Then $a_y = 0$ (object doesn't move along tilted y)

$\Sigma F_{ix} = ma_x$ what we want

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

Quiz 2 60% – 90%

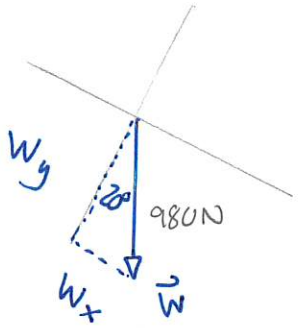
(3) Magnitudes of forces

$$W = mg = 100kg \times 9.8 m/s^2 = 980N$$

(4) Components (in tilted axes)

Quiz3 70%

For the weight



	x	y
$\vec{W}$	335N	-921N
$\vec{n}$	0	n

The trig works differently $\frac{W_x}{980N} = \sin\theta \Rightarrow W_x = 980N \sin 20° = 335N$

$\frac{W_y}{980N} = \cos\theta \Rightarrow W_y = 980N \cos 20° = 921N$

(5) Use Newton's second law:

$\Sigma F_{ix} = ma_x \Rightarrow 335N = 100kg\, a_x$

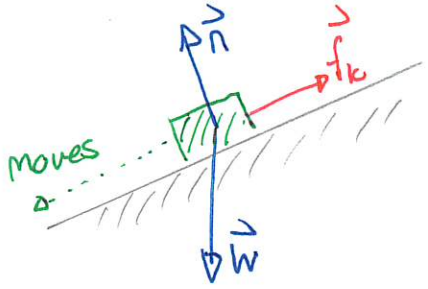
$\Rightarrow a_x = \frac{335N}{100kg} \Rightarrow a_x = 3.35 m/s^2$

$\Sigma F_{iy} = 0 \Rightarrow -921N + n = 0 \Rightarrow n = 921N$

Friction

Friction is a force exerted by one surface on another that tends to oppose motion. There are two types of friction

1) Kinetic friction



Occurs when one surface moves relative to another. This has properties:

a) direction parallel to surface, opposite to motion.

b) magnitude is

$$f_k = \mu_k n$$

where n = magnitude of the normal force

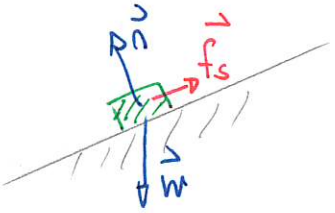
μ_k = coefficient of kinetic friction

depends on the materials in the two surfaces only

Quiz 4 50% - 50%

Quiz 5 50% - 100%

2) Static friction



Occurs when the two surfaces do not move relative to each other. This has properties:

a) direction opposite to that in which motion would otherwise occur.

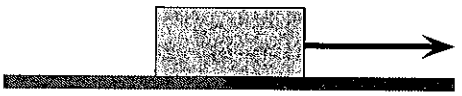
b) magnitude adjusts according to the situation. The maximum possible is

$$f_{s\,max} = \mu_s n$$ Max possible!

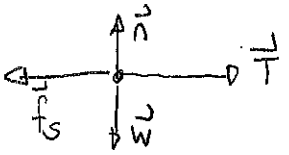
where μ_s = coefficient of static friction

156 Dragging a box horizontally

A 25 kg box can move along a rough horizontal surface. The coefficient of static friction between the box and surface is 0.30. A rope pulls horizontally on the box. Determine the minimum force needed to move the box from rest. *(111F2023)*



Answer: ① FBD



② $\sum F_{ix} = ma_x = 0$ work when we have max friction to keep object at rest $\Rightarrow \vec{a} = 0$

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

③ $w = mg = 25\,kg \times 9.8\,m/s^2 = 245N$

static friction max $f_s = \mu_s n = 0.30n$

④ Components

	x	y
$\vec{w}$	0	$-245N$
$\vec{n}$	0	n
$\vec{T}$	T	0
$\vec{f}_s$	$-0.30n$	0

⑤ $\sum F_{ix} = 0 \Rightarrow T - 0.30n = 0 \Rightarrow T = 0.30n$

$\sum F_{iy} = 0 \Rightarrow -245N + n = 0 \Rightarrow n = 245N$

Thus $T = 0.30 \times 245N = 73.5N$