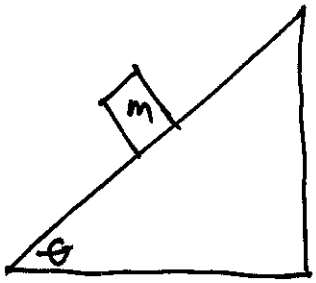
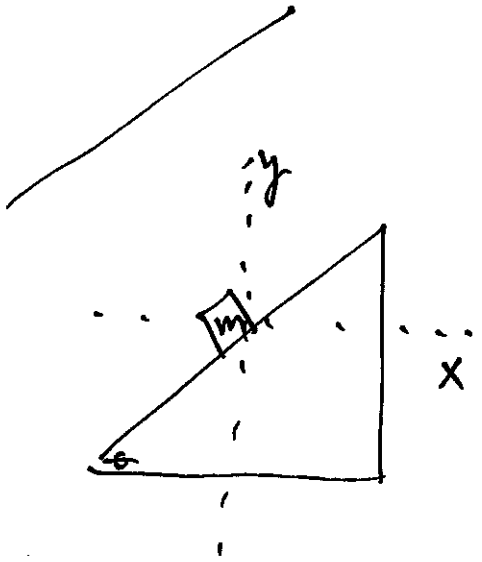
(E) Ramp Problems without Friction



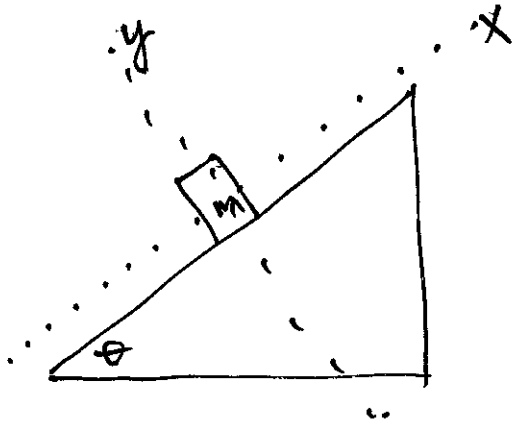

A block of mass m is on a ramp of angle θ.

To correctly analyze this situation we will use a rotated axis to break our forces into components.

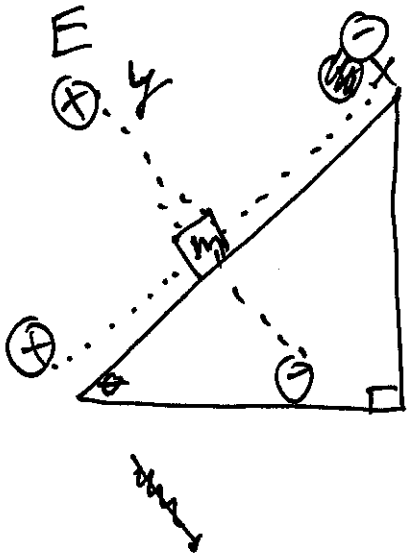
The axes are rotated, so that the x-axis is parallel to the ramp and the y-axis is perpendicular to it.




This is how you typically arrange a coordinate axis




But we will arrange the axes this way instead!




- We have rotated the axes so that the x-axis now parallel to the ramp, and the y-axis is perpendicular to the ramp.
(I've also made ~~+x~~ +x down the ramp)

In a frictionless ramp, only two forces act on the block.

- Gravity and - Normal Force

- Gravity always acts directly down

- Normal Force always acts perpendicular to the surface

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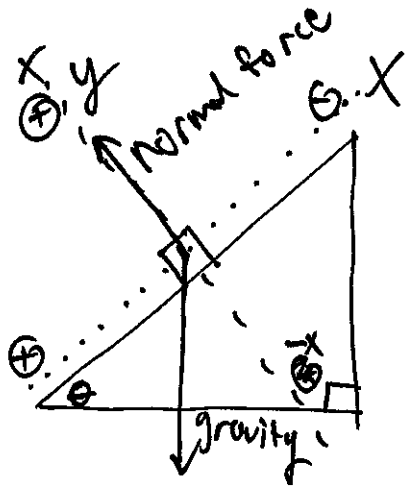
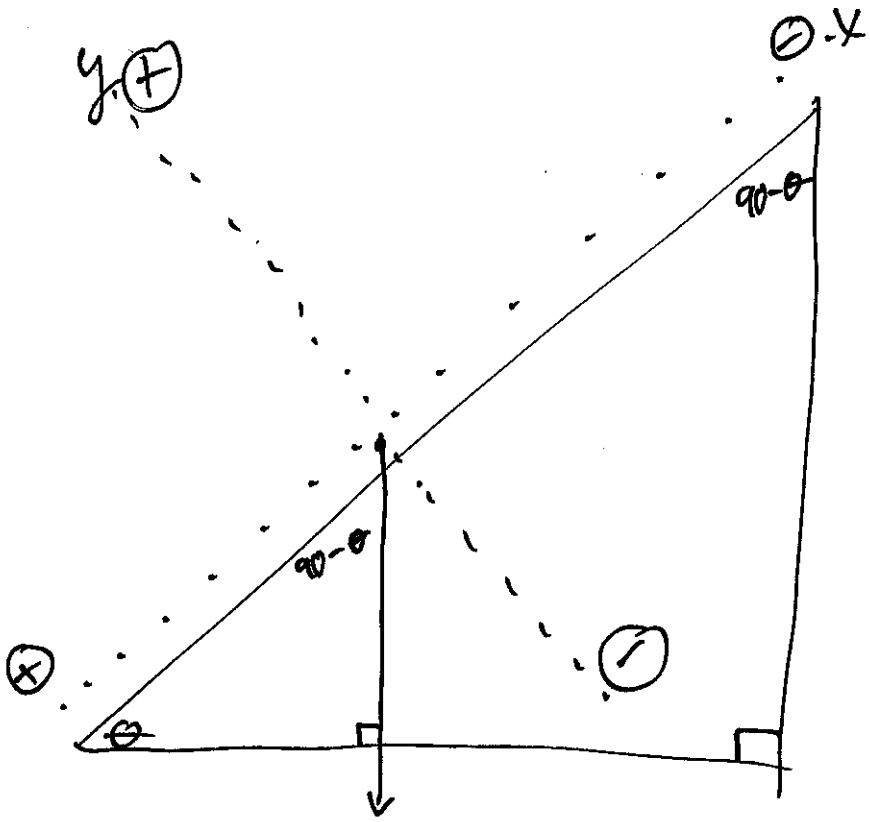



* This means

- Normal force acts in the ±y direction, and does not need to be broken into components.
- Gravity must be broken into components!




How do we find the direction of gravity in our new coordinate system?

- From the diagram above, and using the principle that the sum of the angles of a triangle is 180°, we can see the direction of gravity is $90-\theta$ below the $(+x)$ axis.

In which $\theta$ is the angle of incline of the ramp.

(E)

Magnitudes of forces

- Gravity always has direction directly down

and magnitude given by

$$F_g = mg$$

- The normal force always has direction perpendicular to the surface, and it is a constraint force.

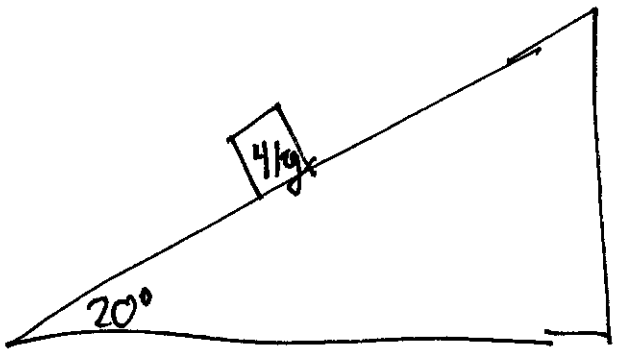
In this case, the normal force acts to keep the block on the ramp.

The normal force will adapt to whatever magnitude is necessary such that

$$\sum F_y = 0.$$

The sum of all y-components of forces is equal to zero.

E.1




-A block with a mass of 4 kg is on a frictionless ramp with an angle of incline of 20°.

(a) Set up a coordinate axis based on the direction of the ramp.

(b) Draw a free-body diagram including only two forces.

(c) Break gravity into components, and fill out the following table:

X-forces

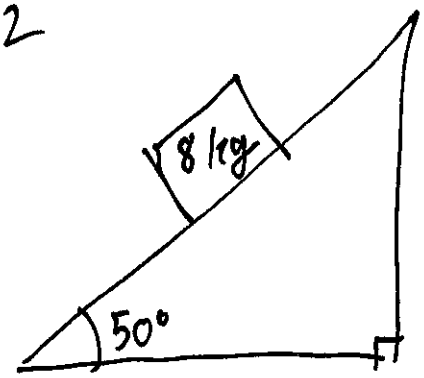
| Force | Magnitude + sign |
|---|---|
| | |

Y-forces

| Force | Magnitude + sign |
|---|---|
| | |

(d) Determine $\Sigma F_x$ and the acceleration of the block.

E.2




- A block with a mass of 8 kg is on a frictionless ramp with an angle of incline of 20°.

(a) Set up a coordinate axis based on the surface of the ramp.

(b) Draw a free-body diagram including only <u>two</u> forces.

(c) Break <u>gravity</u> into components and fill out the following tables:

X-forces

| force | Magnitude+sign |
|---|---|
| | |

Y-forces

| force | Magnitude+sign |
|---|---|
| | |

(d) Determine $\Sigma F_x$ and determine the acceleration of the block $a_x$.