Fri: HW by 5pm

Ex: 164, 167, 171, 172, 174, 177, 180, 184

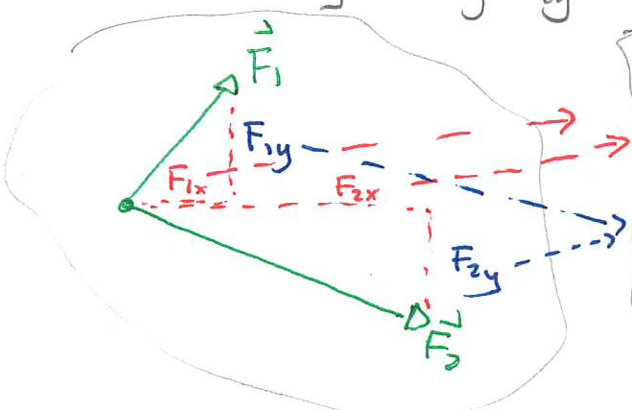
Mon: Warm Up 7

Dynamical situations

In dynamical situations the acceleration of an object is non-zero. Then in component form, Newton's Second Law is:

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

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



insert as much info as possible

$F_{1x} + F_{2x} = ma_x$

$F_{1y} + F_{2y} = ma_y$

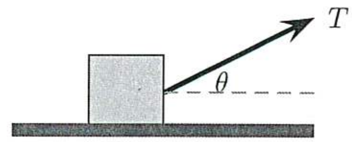
Insert as much info as possible

ALGEBRA does the rest

Warm Up 2 (From previous class)

155 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. *(131F2024)*



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 forces.

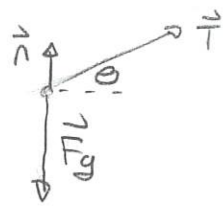
f) Determine an expression for the acceleration of the box.

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

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

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

Answer: a) Draw FBD



b) 2D vertical components cancel. So as T, θ increase n decreases.

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

$\sum F_{iy} = ma_y = 0$ since horizontal motion

d) $F_g = mg$

$T_x = T\cos\theta$ $\quad F_{gx} = 0$ $\quad n_x = 0$

$T_y = T\sin\theta$ $\quad F_{gy} = -mg$ $\quad n_y = n$

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

e) $\sum F_{ix} = Ma_x \Rightarrow T\cos\theta = Ma$

$\sum F_{iy} = 0 \Rightarrow -Mg + T\sin\theta + n = 0$

f) $a = \frac{T}{M}\cos\theta$

g) $-Mg + T\sin\theta + n = 0 \Rightarrow n = Mg - T\sin\theta$

As T increases n decreases

As θ " $\sin\theta$ increases $\Rightarrow$ n decreases.

h) $\theta = 0 \Rightarrow a = T/M = \frac{275N}{45\,kg} \Rightarrow a = 6.1\,m/s^2$

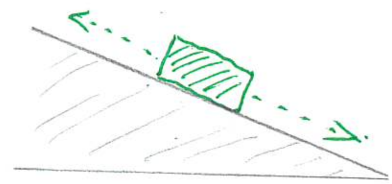
$n = Mg \Rightarrow n = 45kg \times 9.8\,m/s^2 = 441\,N$

i) $\theta = 45° \Rightarrow a = \frac{275N}{45kg}\cos 45° \Rightarrow a = 4.3\,m/s^2$

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

Object on a ramp

We frequently have to consider objects that slide along inclined surfaces. This was one of the first mechanics experiments, originally done by Galileo. He verified that the acceleration in such circumstances was constant



Modern examples of this include:

* skiers, sledders on flat slopes
* vehicles moving up + down inclines.

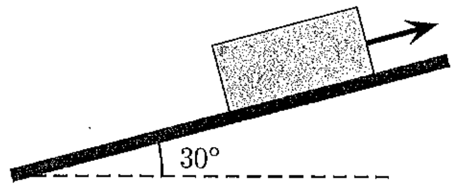
The usual framework of Newtonian mechanics applies.

Quiz 1 30% - 50%
Quiz 2 50% - 60%
Quiz 3 60% -

} 30 - 80%
———
40%

176 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. *(131F2024)*



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

$$F_{\text{net }x} = \Sigma F_{ix} = \cdots \tag{7}$$
$$F_{\text{net }y} = \Sigma F_{iy} = \cdots \tag{8}$$

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
$\vec{\mathbf{F}}_g$		
$\vec{\mathbf{n}}$		
$\vdots$		

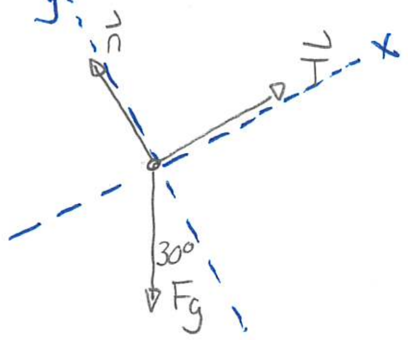
f) Use Eq. (7) to obtain an equation relating various quantities that appear in this problem. Do the same with Eq. (8).Use the resulting equations to determine the acceleration of the box.

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?

Answer:

a)



b) tilt the axes so one is along direction of acceleration

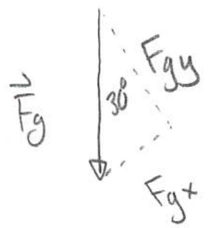
c) $\sum_i \vec{F}_i = m\vec{a}$

$\sum F_{ix} = ma_x$

$\sum F_{iy} = ma_y = 0$ since $a_y = 0$ because there is no motion along y.

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

e)



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

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

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

f) (7) gives $-19.5\,N + 15\,N = ma_x$

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

$\Rightarrow a_x = -1.1\,m/s^2$

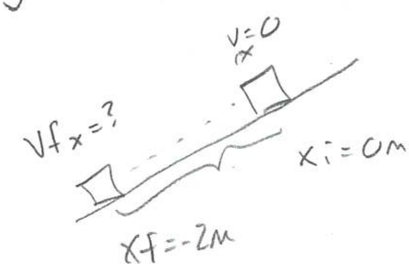
(8) gives $-34\,N + n + 0\,N = 0 \Rightarrow n = 34\,N$

g) No, it could be moving down + speeding up

it " " " up + slowing down

h) $x_f = x_i + v_{ix}\Delta t + \frac{1}{2} a_x \Delta t^2$

$-2.0\,m = 0\,m + 0\,m/s\,\Delta t + \frac{1}{2}(-1.1\,m/s^2)\Delta t^2$



$\Rightarrow -2.0\,m = -0.55\,m/s^2\,\Delta t^2$

$\Rightarrow \Delta t^2 = 3.64\,s^2 \Rightarrow t = 1.9\,s$