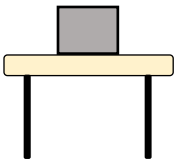
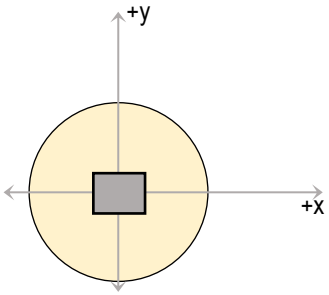
## CONCEPT: 2D FORCES IN HORIZONTAL PLANE

EXAMPLE: A 5kg block on a circular tabletop is pulled by 2 horizontal forces. If $F_1$ = 2N along +x-axis and $F_2$ = 5N at 37°, find **(a)** $\vec{F}_{net}$, **(b)** $a_x$, **(c)** $a_y$, **(d) a.**

**Side View**



**Top View**




| 2D FORCES |
|---|
| **1)** Draw FBD: **W,$F_A$,T,N,$f$** |
| **2)** Decompose 2D Forces |
| **3)** Write $\boldsymbol{\Sigma F = ma}$ in x & y |
| **4)** Solve |

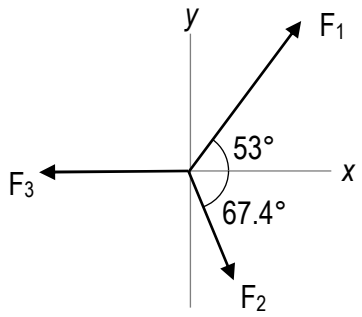
| | x | y |
|---|---|---|
| $\vec{F}_1$ | | |
| $\vec{F}_2$ | | |
| $\vec{F}_{net}$ = _____ | | |

- IF applied forces act only in the horizontal plane, N = ____
  - $\Sigma F_{vert} = 0$ (in the side view), so vertical forces (weight, Normal) aren't important.
- Because Forces = vectors, when a Force acts at an angle in 2D, we must _____ it into its **x** & **y** components.
  - If multiple forces acting, $F_{net}$ is always calculated using _____.

PROBLEM**:** Three horizontal forces act on a box (mass = 8 kg) sitting on a smooth surface. $\mathbf{F}_1$ is 30 N acting at 53° counterclockwise from the +x axis, $\mathbf{F}_2$ is 13 N acting at 67.4° clockwise from the +x axis, and $\mathbf{F}_3$ is 20 N directly along the -x axis. What are the magnitude and direction of the box's acceleration?

**A)** 1.5 m/s$^2$, 14° ccw from +x-axis
**B)** 1.5 m/s$^2$, 76° ccw from +x-axis
**C)** 6.9 m/s$^2$, 1.1° cw from -x-axis
**D)** 6.9 m/s$^2$, 0.46° cw from -x-axis

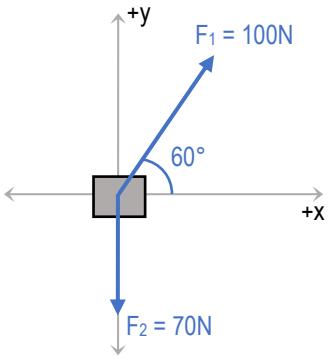
| **2D FORCES** |
| --- |
| **1)** Draw FBD |
| **2)** Write $\boldsymbol{\Sigma F = ma}$ in x & y |
| **3)** Solve |



## CONCEPT: SOLVING AN UNKNOWN 2D FORCE

- In some problems, you'll have to solve for a Force *without* knowing its magnitude **OR** direction from the problem.
  - When expanding **ΣF=ma** in X&Y, assume the components of unknown forces are _____.

EXAMPLE: Three horizontal forces pull a 40kg block. $F_1$ = 100N at 60° above the +x-axis, $F_2$ = 70N along the -y axis. Find the magnitude of the third force required so that the block accelerates at 2m/s$^2$ *only* along the x-axis.




| | x | y |
|---|---|---|
| $\vec{F}_1$ | | |
| $\vec{F}_2$ | | |
| | | |
| $\vec{F}_{net}$ = _____ | | |

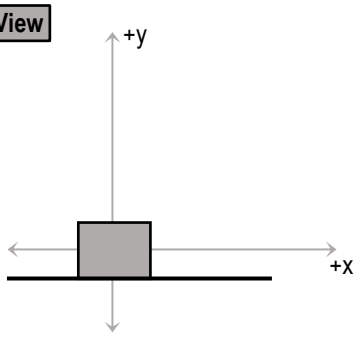
**2D FORCES**

**1)** Draw FBD: **W,$F_A$,T,N,$f$**
**2)** Decompose 2D Forces
**3)** Write $\Sigma F = ma$ in x & y
**4)** Solve

## CONCEPT: 2D FORCES IN HORIZONTAL & VERTICAL PLANES

EXAMPLE: A 5.1kg block on the floor is pulled by a 10N force 37° above the horizontal. Assuming no friction, find **(a)** the Normal force on the block; **(b)** the block's acceleration.

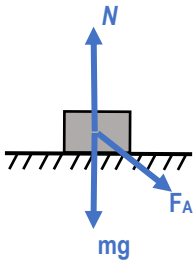
**Side View** **Top View**




| 2D FORCES |
| --- |
| **1)** Draw FBD: **W,$F_A$,T,N,$f$** |
| **2)** Decompose 2D Forces |
| **3)** Write $\Sigma F = ma$ in x & y |
| **4)** Solve |

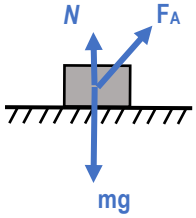
● IF applied forces act partially/completely vertically, then N _____.

- In most problems, $F_{up} < F_{down}$, so the object is in equilibrium in the y-axis: $\Sigma F_y = 0 \Leftrightarrow a_y = 0$



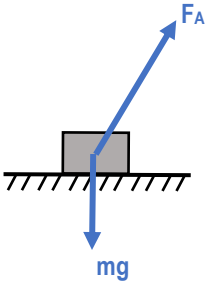

- Push down

***N*** ***mg***




- Pull up, not enough to lift ($F_{up} < F_{down}$)

***N*** ***mg***




- Pull up, enough to lift ($F_{up} > F_{down}$)

***N***

PROBLEM**:** You push a 5.1kg cart along the floor with an unknown force **F** at 30° below the horizontal**.** Using a scale, you know the Normal force is 70N**.** What is the horizontal acceleration of the cart?

**A)** 7.84 m/s$^2$
**B)** 3.92 m/s$^2$
**C)** 6.79 m/s$^2$
**D)** 2.26 m/s$^2$

**2D FORCES**

**1)** Draw FBD**: W,F$_A$,T,N,$f$**
**2)** Decompose 2D Forces
**3)** Write $\boldsymbol{\Sigma F = ma}$ in x & y
**4)** Solve

PROBLEM**:** You drop a 2-kg box straight down from the top of a building**.** A steady horizontal wind exerts a constant force of 3 N on the box as it falls**.** (Ignore other air resistance**.**) What is the direction of the box's acceleration?

**A)** 1.4° below horizontal
**B)** 8.7° below horizontal
**C)** 81° below horizontal
**D)** 33° below horizontal
**E)** Not enough information to tell

| **2D FORCES** |
| --- |
| **1)** Draw FBD<br>**2)** Write $\boldsymbol{\Sigma F = ma}$ in x & y<br>**3)** Solve |