PHYS 1443 – Section 004
Lecture #8

Tuesday, Sept. 16, 2014

Dr. Jaehoon Yu

- Newton's Laws of Motion
  - Mass
  - Newton's second law of motion
  - Newton's third law of motion
  - Categories of Forces
  - Gravitational Force and Weight
  - Force of Friction

Announcements

- Quiz #2 results
  - Class average: 23.3/45
    - Equivalent to 51.8/100
    - Previous quiz: 71.7/100
  - Top score: 45/45
- Reminder for Term exam #1
  - In class Thursday, Sept. 25. Do NOT Miss the exam!
  - Covers CH1.1 through what we learn Tuesday Sept. 23 plus the math refresher
  - Mixture of multiple choice and free response problems
  - Bring your calculator but DO NOT input formula into it!
    - Your phones or portable computers are NOT allowed as a replacement!
  - You can prepare a one 8.5x11.5 sheet (front and back) of **handwritten** formulae and values of constants for the exam
    - None of the parts of the solutions of any problems
    - No derived formulae, derivations of equations or word definitions!
- Two colloquia this week:
  - Dr. Haleh Hadavand, 4pm today, in SH103
  - Dr. Manfred Cuntz, 4pm, tomorrow, in SH101

Physics Department
The University of Texas at Arlington
Special COLLOQUIUM

Properties of the Higgs like Particle at 125 GeV and Beyond Standard Model Higgs Using the ATLAS Experiment

Dr. Haleh Hadavand

The University of Texas at Arlington
The Physics Department

4:00 pm Tuesday September 16, 2014 room 103 Science Hall

Abstract:

Since the discovery of the Higgs like particle discovered at the LHC on July 4, 2012, the ATLAS experiment has analyzed some 10-15 fb-1 more data. We can now measure the spin and mass of this particle to a greater level of accuracy. We also have more accurate information about the branching fraction to the various final states. Although this particle is consistent with a Standard Model Higgs, many Beyond Standard Model scenarios are still viable. One of these models is Super-Symmetry where they postulate 5 Higgs Bosons. I will show results of searches for the Charged Higgs Boson in the Super-Symmetric model and show other evidence which points to the viability of these Models.

Physics Department
The University of Texas at Arlington
COLLOQUIUM

UV Habitability around Main-Sequence Stars

Dr. Manfred Cuntz

The University of Texas at Arlington
The Physics Department

4:00 pm Wednesday September 17, 2014 room 101 Science Hall

Abstract:

Besides the notion of the climatological habitable zone around the Sun and other main-sequence stars, there is heightened interest in the role(s) of UV radiation regarding the provision of habitability. Recent work has focused on F-type stars, which often receive little attention from the scientific community. Those are characterized by rapid stellar evolution. Detailed studies show that the estimated biological damage for planets at Earth-equivalent positions is noticeably higher than for planets hosted by solar-like stars, though the results are far from hopeless. While for F-type stars photospheric radiation is most decisive, it is found that for stars of, e.g., spectral type K chromospheric radiation at young stellar ages is most significant. The latter is determined by magnetic heating processes, which are largely controlled by stellar dynamo activity. Interesting phenomena also occur in stellar binary systems, where habitability requires a large set of additional considerations owing to stellar radiative and gravity constraints. Studies of stellar UV habitability are in part motivated by previous findings indicating that the stellar UV environment is a decisive factor in determining the suitability of exosolar planets and exomoons for biological evolution and sustainability.

Refreshments will be served at 3:30 p.m. in the Physics Lounge

Force

We've been learning kinematics; describing motion without understanding what the cause of the motion is. Now we are going to learn dynamics!!

Can someone tell me what FORCE is?

FORCE is what causes an object to move.

The above statement is not entirely correct. Why?

Because when an object is moving with a constant velocity no force is exerted on the object!!!

FORCEs are what cause changes to the velocity of an object!!

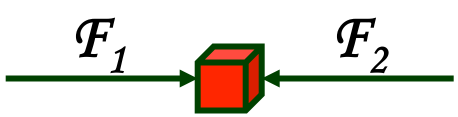
What does this statement mean?

When there is force, there is change of velocity!!

What does force cause? It causes an acceleration.!!

What happens if there are several forces being exerted on an object?

Forces are vector quantities, so vector sum of all forces, the NET FORCE, determines the direction of the resulting acceleration of the object.



NET FORCE, $F = F_1 + F_2$

When the net force on an object is **0**, *it has constant velocity and is at its equilibrium!!*

More Forces

There are various classes of forces

Contact Forces: Forces exerted by physical contact of objects

Examples of Contact Forces: Baseball hit by a bat, Car collisions

Field Forces: Forces exerted without physical contact of objects

Examples of Field Forces: Gravitational Force, Electro-magnetic force

What are possible ways to measure the strength of a force?

A calibrated spring whose length changes linearly with the force exerted .

Forces are vector quantities, so the addition of multiple forces must be done following the rules of vector additions.

Newton's First Law and Inertial Frames

Aristotle (384-322BC): *The natural state of a body is rest. Thus force is required to move an object. To move faster, ones needs larger forces.*

Galileo's statement on natural states of matter: *Any velocity once imparted to a moving body will be rigidly maintained as long as the external causes of retardation are removed!!*

Galileo's statement is formulated by Newton into the **1st law of motion (Law of Inertia)**: *In the absence of external forces, an object at rest remains at rest and an object in motion continues in motion with a constant velocity.*

What does this statement tell us?

- When no net force is exerted on an object, the velocity of the object cannot change
  - This means that the object cannot accelerate.
- Objects would like to keep its current state of motion, as long as there are no net force that interferes with the motion. This tendency is called the Inertia.

A frame of reference that is moving at a constant velocity is called the ***Inertial Frame.***

The Newtonian mechanics holds in an ***Inertial reference Frame.***

Is a frame of reference with an acceleration an ***Inertial Frame?***

NO!

Mass

Mass: *A measure of the inertia of an object* or *the quantity of matter*

- A fundamental property of matter
- Independent of the object's surroundings: The same no matter where you go.
- Independent of the method of measurement: The same no matter how you measure it.

The heavier the object, the bigger the inertia !!

It is harder to make changes of motion of a heavier object than a lighter one.

The same forces applied to two different masses result in different accelerations depending on the mass.

$$\boxed{\frac{m_1}{m_2} \equiv \frac{a_2}{a_1}}$$

Note that the mass and the weight of an object are two different quantities!!

Weight of an object is the magnitude of the gravitational force exerted on the object.

Not an inherent property of an object!!!

Weight will change if you measure on the Earth or on the moon but the mass won't!!

Unit of mass? kg

Newton's Second Law of Motion

The acceleration of an object is directly proportional to the net force exerted on it and is inversely proportional to the object's mass.

How do we write the above statement in a mathematical expression?

$$\vec{a} = \frac{\sum_i \vec{F}_i}{m}$$

From this we obtain

$$\boxed{\sum_i \vec{F}_i = m\vec{a}}$$

Newton's 2nd Law of Motion

Since force is a vector quantity, each component must also satisfy:

$$\boxed{\sum_i F_{ix} = ma_x} \qquad \boxed{\sum_i F_{iy} = ma_y} \qquad \boxed{\sum_i F_{iz} = ma_z}$$

When working with forces, one must identify an object and only the forces act on that object, no other forces!

Unit of Force

From the vector expression in the previous page, what do you conclude the dimension and the unit of the force are?

$$\boxed{\sum_i \vec{F_i} = m\vec{a}}$$

The dimension of force is $[m][a] = [M][LT^{-2}]$

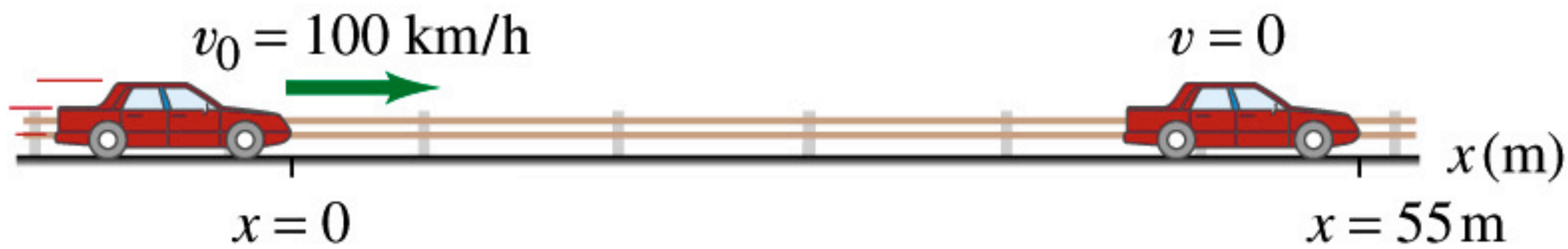
The unit of force in SI is $[Force] = [m][a] = [M][LT^{-2}] = (\mathrm{kg})\left(\frac{\mathrm{m}}{\mathrm{s}^2}\right) = kg \cdot m/s^2$

For ease of use, we define a new derived unit called, Newton (N)

$$\boxed{1N \equiv 1kg \cdot m/s^2 \approx \frac{1}{4} lbs}$$

Example for Force

What constant net force is required to bring a 1500kg car to rest from a speed of 100km/h within a distance of 55m?



What do we need to know to figure out the force?

Acceleration!!

What are given? Initial speed: $v_{xi} = 100km/h = 28m/s$ Final speed: $v_{xf} = 0m/s$

Displacement: $\Delta x = x_f - x_i = 55m$

This is a one dimensional motion. Which kinetic formula do we use to find acceleration?

$$v_{xf}^2 = v_{xi}^2 + 2a_x\left(x_f - x_i\right)$$

Acceleration

$$a_x = \frac{v_{xf}^2 - v_{xi}^2}{2\left(x_f - x_i\right)} = \frac{-\left(28m/s\right)^2}{2\left(55m\right)} = -7.1m/s^2$$

Thus, the force needed to stop the car is

$$F_x = ma_x = 1500kg \times \left(-7.1m/s^2\right) = -1.1 \times 10^4 N$$

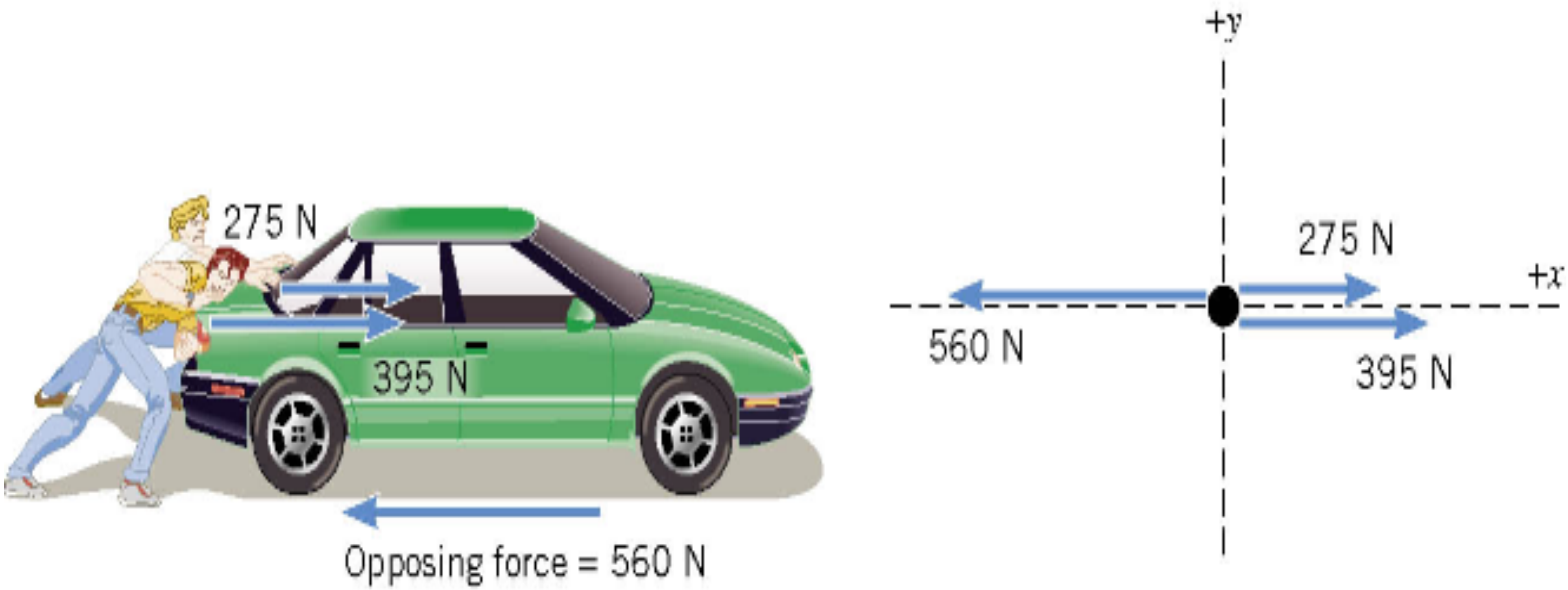
Given the force how far does the car move till it stops?

$$\Delta x = x_f - x_i = \frac{v_{xf}^2 - v_{xi}^2}{2a_x} = \frac{m\left(v_{xf}^2 - v_{xi}^2\right)}{2ma_x} = \frac{m\left(v_{xf}^2 - v_{xi}^2\right)}{2F_x}$$

- Linearly proportional to the mass of the car
- Squarely proportional to the speed of the car
- Inversely proportional to the force by the brake

Free Body Diagram

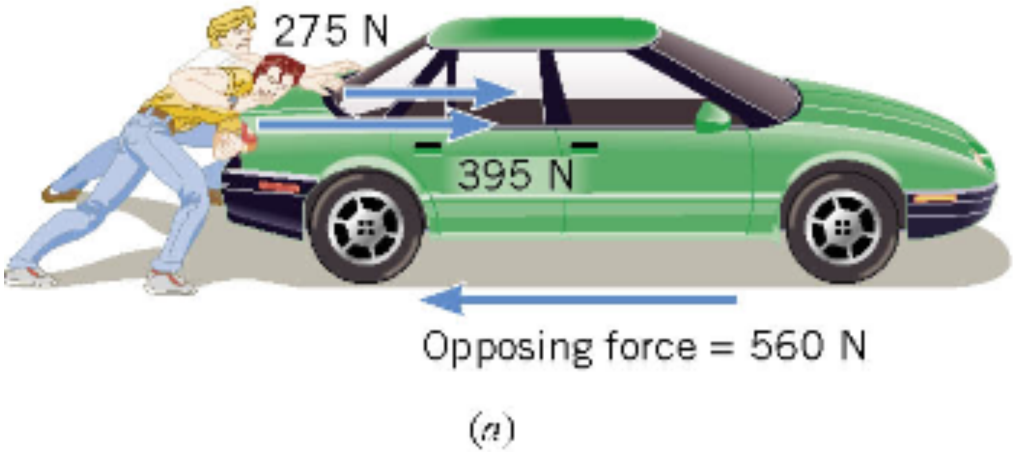
A ***free-body-diagram*** is a diagram that represents the object and the forces that act on it.

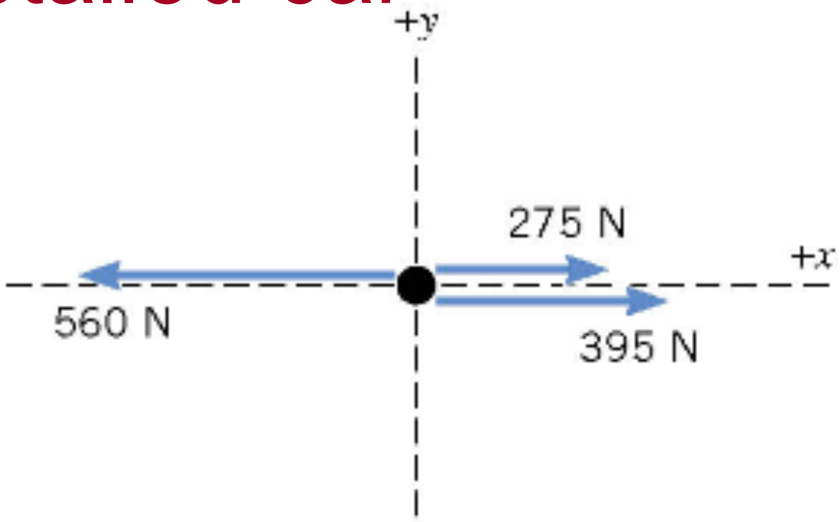


(a)

(b) Free-body diagram of the car

Ex. Pushing a stalled car





(b) Free-body diagram of the car

What is the net force in this example?

$$F = 275\text{ N} + 395\text{ N} - 560\text{ N} = +110\text{ N}$$

Which direction? The + x axis of the coordinate system.

What is the acceleration the car receives?

If the mass of the car is 1850 kg, then by Newton's second law, the acceleration is

$$\sum \vec{F} = m\vec{a}$$

Since the motion is in 1 dimension

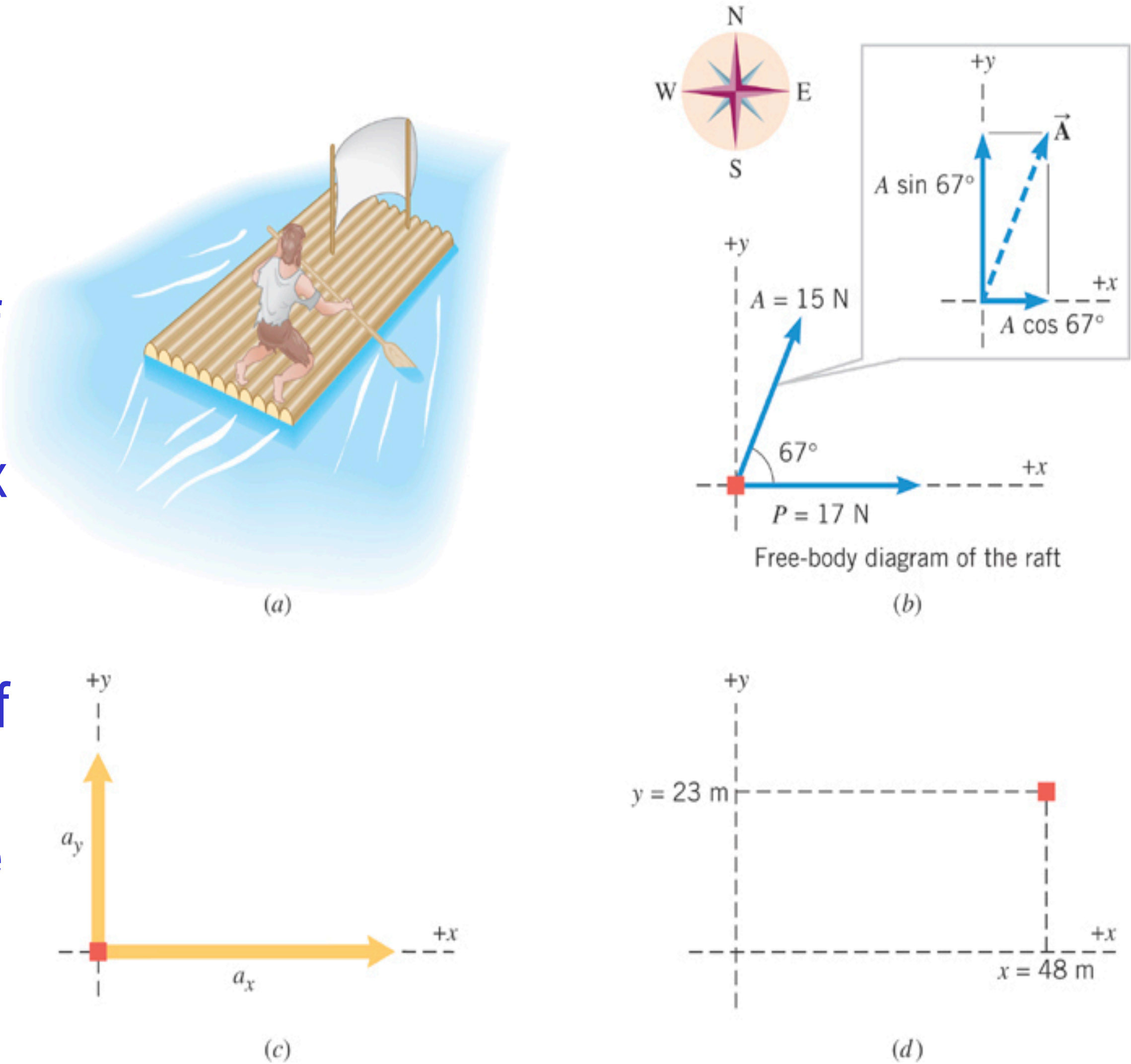
$$\sum F = ma$$

Now we solve this equation for a

$$a = \frac{\sum F}{m} = \frac{+110\,\mathrm{N}}{1850\,\mathrm{kg}} = +0.059\,\mathrm{m/s^2}$$

Ex. Stranded man on a raft

A man is stranded on a raft (mass of man and raft = 1300kg)m as shown in the figure. By paddling, he causes an average force **P** of 17N to be applied to the raft in a direction due east (the +x direction). The wind also exerts a force **A** on the raft. This force has a magnitude of 15N and points 67° north of east. Ignoring any resistance from the water, find the x and y components of the rafts acceleration.



First, let's compute the net force on the raft as follows:

Force	*x* component	*y* component
$\vec{\mathbf{P}}$ $\vec{\mathbf{A}}$	$+17$ N $+(15\text{N})\cos 67^{o}$	0 N $+(15\text{N})\sin 67^{o}$
$\vec{F}=\vec{P}+\vec{A}$	$+17+15\cos 67^{o}=$ $+23(\text{N})$	$+15\sin 67^{o}=$ $+14(\text{N})$

Now compute the acceleration components in x and y directions!!

$$a_x = \frac{\sum F_x}{m} = \frac{+23\ \text{N}}{1300\ \text{kg}} = +0.018\ \text{m/s}^2$$

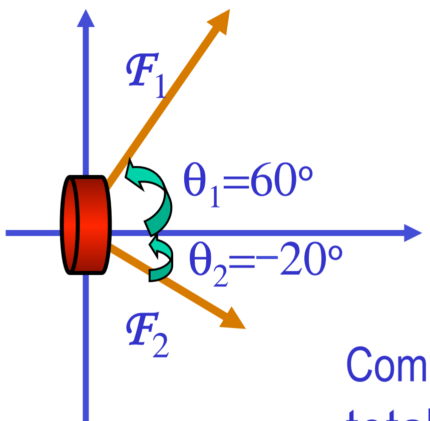
$$a_y = \frac{\sum F_y}{m} = \frac{+14\ \text{N}}{1300\ \text{kg}} = +0.011\ \text{m/s}^2$$

And put them all together for the overall acceleration:

$$\vec{a} = a_x \vec{i} + a_y \vec{j} = \left(0.018\vec{i} + 0.011\vec{j}\right) m/s^2$$

Example for Newton's 2nd Law of Motion

Determine the magnitude and direction of the acceleration of the puck whose mass is 0.30kg and is being pulled by two forces, **F1** and **F2,** as shown in the picture, whose magnitudes of the forces are 8.0 N and 5.0 N, respectively.



Components of $\mathcal{F}_1$

$$F_{1x} = \left|\vec{F}_1\right| \cos\theta_1 = 8.0\times\cos\left(60^\circ\right) = 4.0N$$

$$F_{1y} = \left|\vec{F}_1\right| \sin\theta_1 = 8.0\times\sin\left(60^\circ\right) = 6.9N$$

Components of $\mathcal{F}_2$

$$F_{2x} = \left|\vec{F}_2\right| \cos\theta_2 = 5.0\times\cos\left(-20^\circ\right) = 4.7N$$

$$F_{2y} = \left|\vec{F}_2\right| \sin\theta_2 = 5.0\times\sin\left(-20^\circ\right) = -1.7N$$

Components of total force $\mathcal{F}$

$$F_x = F_{1x} + F_{2x} = 4.0 + 4.7 = 8.7N = ma_x$$

$$F_y = F_{1y} + F_{2y} = 6.9 - 1.7 = 5.2N = ma_y$$

Magnitude and direction of acceleration a

$$a_x = \frac{F_x}{m} = \frac{8.7}{0.3} = 29m/s^2 \quad a_y = \frac{F_y}{m} = \frac{5.2}{0.3} = 17m/s^2 \quad \left|\vec{a}\right| = \sqrt{\left(a_x\right)^2 + \left(a_y\right)^2} = \sqrt{\left(29\right)^2 + \left(17\right)^2} = 34m/s^2$$

$$\theta = \tan^{-1}\left(\frac{a_y}{a_x}\right) = \tan^{-1}\left(\frac{17}{29}\right) = 30^\circ$$

Acceleration Vector *a*

$$\vec{a} = a_x\hat{i} + a_y\hat{j} = \left(29\hat{i} + 17\hat{j}\right)m/s^2$$