Common Exam 1
8:30-9:45 am Friday, Oct. 2nd (Arrive by 8:15 am)
TIER 116 (Tiernan Lecture Hall 1)
Bring calculators
Chapters 1 - 3, up to projectile motion

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Review session: part of 10/1 Thursday class
HW #4: 2D motion (Due 1 pm central time, 10/1, Thursday).
HW #5: Newton's laws (Due 1 pm central time, 10/7, Wednesday).

Last class...

Chapter 3. Vectors and 2-dimensional motion

Equations for Projectile motion

\[ v_x = v_{0x} \]
\[ v_y = v_{0y} - gt \]
\[ x = x_0 + v_{0x} t \]
\[ y = y_0 + v_{0y} t - \frac{1}{2} gt^2 \]
\[ v_y^2 - v_{0y}^2 = -2g(y - y_0) \]

Today... Chapter 4. Laws of Motion

Force
Net force
Newton's 1st, 2nd, 3rd laws
Chapter 4: The Laws of Motion

Motivation
So far, we learned about
- Units, 1d motion, 2d motion, vectors, ...
  → How to describe motions
Then, what causes the motion ??
  What causes an apple to fall?
  What causes a ball to fly in parabola?

Answer → Chapter 4: The Laws of Motion

Today, Forces, Newton’s 1st, 2nd, and 3rd laws

Forces
The measure of interaction between two objects (pull or push).
Vector - force has magnitude (unit: N, Newton) and direction
Force on one object from the other object

Example
- Force on apple from your hand
- Gravitational Force on apple from earth

- apple
- Your hand
- Earth
Net Force \( \vec{F}_{net} \)

If forces from many objects are applied on a single object

Net force: Vector sum of forces

\[
\vec{F}_{\text{net on apple}} = \vec{F}_{\text{hand}} + \vec{F}_{\text{gravity}}
\]

Newton’s First Law of Motion (The Law of Inertia)

If net force on an object is zero,
the object at rest remains at rest,
the object moving continues to move with the same velocity
(same speed and same direction).

If \( \vec{F}_{net} = 0 \), \( \vec{v} \) does not change.

An additional force is NOT required to keep a cart moving
with a constant velocity on a frictionless track!
iClicker Quiz

\[ v = 2.5 \text{ m/s} \]

\[ | F_1 | = 5 \text{ N} \quad | F_2 | = ? \text{ N} \]

A block is moving to the right at a constant velocity 2.5 m/s on a frictionless horizontal surface.

Two forces \( F_1 \) and \( F_2 \) are acting on the block as shown above.

If \( F_1 \) has a magnitude of 5 N, then the magnitude of \( F_2 \) is ______.

(a) Equal to 5 N

(b) Greater than 5 N

(c) Less than 5 N

---

**Newton's Second Law of Motion**

If \( \vec{F}_{net} \neq 0 \), \( \vec{v} \) changes, in other words, accelerates.

- **Non-zero net force** causes object to accelerate.
- An object of mass \( m \) has an acceleration \( \vec{a} \), equal to the net force \( \vec{F} \), divided by the mass of the object, \( m \).

\[
\vec{a} = \frac{\sum \vec{F}}{m} = \frac{\vec{F}_{net}}{m}
\]

\[
\vec{a} = \frac{\vec{F}_{net}}{m}
\]
\[ \vec{a} = \sum \frac{\vec{F}}{m} = \frac{\vec{F}_{\text{net}}}{m} \Rightarrow \vec{F}_{\text{net}} = m\vec{a} \]

\[ [1N] = [1kg] \times \left[ \frac{1m}{s^2} \right] \]

SI unit of force is a Newton: \( 1N \equiv 1 \frac{kg \cdot m}{s^2} \)

Non-SI unit for force: pound (lb) \( 1N = 0.225 \text{ lb} \)

Newton’s 2\textsuperscript{nd} law for each component

\[ F_{\text{net},x} = ma_x; \quad F_{\text{net},y} = ma_y; \quad F_{\text{net},z} = ma_z \]

iClicker quiz

If the net force acting on an object is in the positive \( x \)-direction, the _____ of the object is always in the positive \( x \)-direction.

(a) displacement
(b) velocity
(c) acceleration
In this projectile motion, while the ball is going up, the direction of the net force is

(a) \[
\begin{array}{c}
\end{array}
\]
(b) \[
\begin{array}{c}
\end{array}
\]
(c) \[
\begin{array}{c}
\end{array}
\]
(d) \[
\begin{array}{c}
\end{array}
\]
(e) \[
\begin{array}{c}
\end{array}
\]

---

iClicker Quiz

1. A block of mass 5 N is subjected to a force of 4 m/s² upward. Which of the following is the correct acceleration?
   (a) 1 m/s²
   (b) 2 m/s²
   (c) 4 m/s²
   (d) 8 m/s²
   (e) 16 m/s²

2. A block of mass 10 N is subjected to a force of 2 F₁. What is the acceleration?
   \[ a = \text{?} \]
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