Physics 101H

General Physics 1 – Honors

Lecture 10 – 9/16/22

Forces

Summary

Topics

Yesterday: kinematics in 2D

- Circular motion
- Relative velocity
- Galilean transformations

Today: Forces [chapter 5]

- Types of force
- Force examples

Announcements

Next week: **No class on Thursday or Friday!**

Dynamics

We finally get to explain motion, not just describe it

Dynamics

Kinematics is the description of the motion of objects

Dynamics is the explanation of the cause of the motion of objects

We have studied kinematics in one and two dimensions, and we are now going to turn to dynamics (initially in one dimension)

We are now chiefly concerned with the **forces acting on** an object

Multiple choice

Instructions: Consider the following question. After you have had a chance to think, I will ask you to raise your hands to indicate your answer.

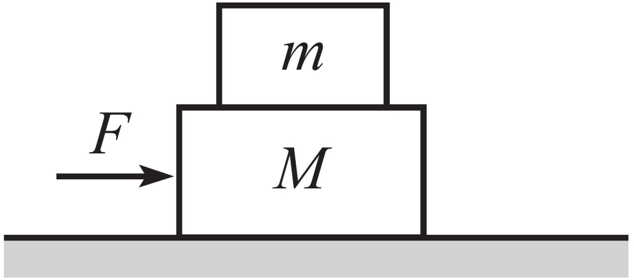
Question: You accelerate two blocks by pushing on the bottom block with a force *F*. The top block moves along with the bottom block. What force directly causes the top block to accelerate?

(a) the normal force between the blocks

(b) the friction force between the blocks

(c) the gravitational force on the top block

(d) the force you apply to the bottom block



Forces

What causes an object to move? A force!

But what is a force? There are two types:

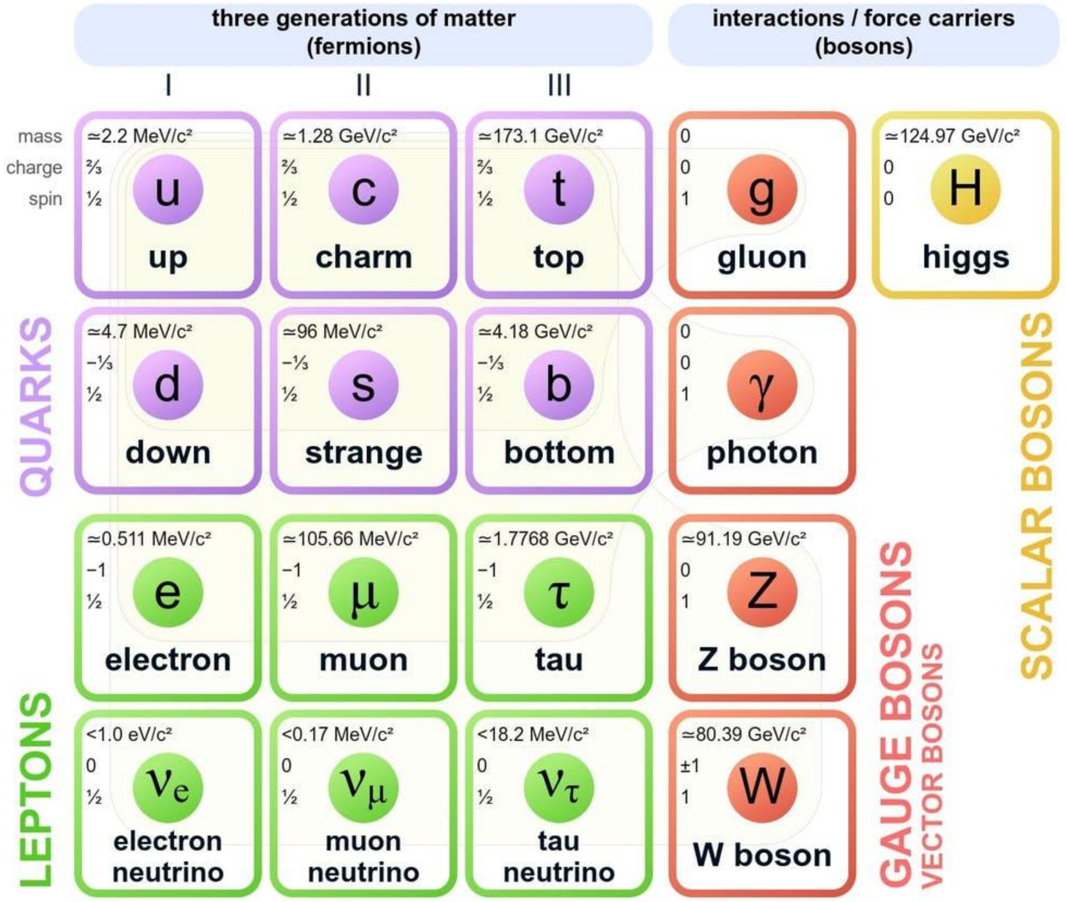
- Contact forces
- Field forces

Fundamental forces

- **Electromagnetic force**
  Attraction and repulsion of electrically charged particles
- **Weak nuclear force**
  Responsible for decay of radioactive nuclei
- **Strong nuclear force**
  Binds together quarks and gluons into protons and neutrons, and protons and neutrons into nuclei
- **Gravitational force**
  Attractive force between massive objects (objects with mass)

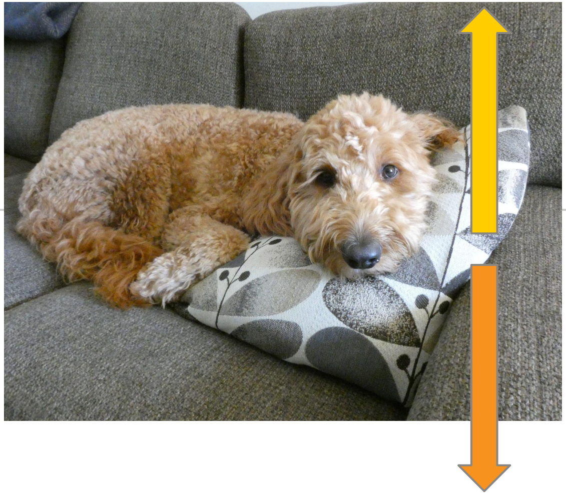
Standard model of particle physics

Describes interactions of fundamental particles (smallest known units of matter in the observable universe) via electromagnetic, weak and strong forces



If these four forces are the only ones we know about - what causes contact forces?

Types of contact force



- **Tension**
  When you pull on a rope, the rope pulls back
- **Normal force**
  When you push on a surface, the surface pushes back
- **Spring tension**
  When you pull on a spring, the spring definitely pulls back
- **Friction**
  This one is surprisingly tricky and not entirely like the others

Two other types of force

Gravity generates a downward force

- Acceleration due to gravity depends on the (mass of the) planet
- Note that **weight** and **mass** are not the same!

Pound-force should not be confused with pound-mass (lb), often simply called *pound*, which is a unit of mass, nor should these be confused with foot-pound (ft·lbf), a unit of energy, or pound-foot (lbf·ft), a unit of torque.

Centripetal forces are any force that keeps an object moving in circular motion

- Not a distinct type of force, but caused by other forces

DON'T CONFUSE *CENTRIPETAL* FORCES (REAL!) WITH *CENTRIFUGAL* FORCES (NOT REALLY REAL!)

Problem solving in pairs

Instructions: Attempt the following question with a neighbour. Your answers will not be graded; your discussion is for your own learning. It is ok if you do not complete the question, but make sure you identify the key steps and write down the main equations.

Question: A firefighter a horizontal distance d from a burning building directs a stream of water from a fire hose at an angle θ above the horizontal. If the initial speed of the stream is v, at what height does the water strike the building (express your result in terms of d, v, θ, and g)?

Summary

Topics

This week
- 2D motion
- Uniform circular motion
- Nonuniform motion
- Forces

Next week
- Newton's laws
- Noninertial reference frames
- Work and energy

Today: Forces [chapter 5]
- Types of force
- Force examples

Monday: Newton's laws [chapter 5]
- First law
- Second law
- Third law

Announcements

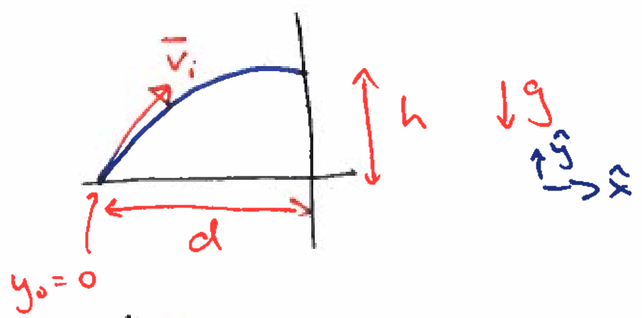
Next week: No class on Thursday or Friday!

NEXT WEEK:
NO CLASS ON THURSDAY OR FRIDAY

PHYSICS 101 - HONORS

Lecture 10 9/16/22

Firefighter example



$$\bar{v}_i = \overbrace{v_i \cos\theta}^{v_{ix}}\, \hat{x} + \overbrace{v_i \sin\theta}^{v_{iy}}\, \hat{y}$$

x-axis motion $\quad v_{ix} = v_i \cos\theta$

$$d = v_{ix} t \quad \Rightarrow \quad t = \frac{d}{v_i \cos\theta}$$

y-axis motion $\quad h = \frac{1}{2}(-g)t^2 + v_{iy} t + 0$

$$= \frac{-g}{2}\left(\frac{d}{v_i \cos\theta}\right)^2 + v_i \sin\theta \left(\frac{d}{v_i \cos\theta}\right)$$

$$= -\frac{g\, d^2}{2 v_i^2 \cos^2\theta} + d \tan\theta$$

Forces (slide 7)

N.B 1 lb is force required to accelerate one slug to 1 ft/s². 1 slug = 14.593

$\Rightarrow$ 1 N $\approx \frac{1}{4}$ lb ~ 1 apple

Force "=" a push or pull

↑ vector!

units are Newtons $\quad$ 1N = 1kg m/s²

Contact force - physical contact between objects

Field force - acts through empty space

Forces (slide 11)

Tension if you pull on a rope, the rope pulls back (same magnitude, opposite direction)

$\uparrow T$ (tension)

$\downarrow W = mg$ (gravity)

free-body diagrams (draw only forces <u>on</u> object)

Normal force
perpendicular to surface

$\uparrow N$ (normal)

$\downarrow W = mg$ (gravity)

Spring tension if you pull on a spring, the spring pulls back
restoring force

$$\bar{F} = -k\,\bar{x}$$

$\bar{F}$: force
$-$: restoring
k: spring constant
$\bar{x}$: displacement

Hooke's law

Friction resistance to relative motion for two objects in contact
caused by electrostatic forces
depends on how strongly contact points are pushed together, but <u>not</u> on area

static friction (before slipping)
$F_s \leq \mu_s N$
μ_s: coefficient of static friction

Friction

$F_{s\,max}$

slipping starts

$F = \mu_k N$ kinetic friction (once moving)

$F_{applied}$

Gravity (slide 12)

Attractive force between two masses

Near the Earth's surface $F = mg$

Weight is size of force acting on an object of mass m

$\Rightarrow$ [weight] = N $\qquad [m] = kg$

Weight depends on planet, mass does not!

Centripetal force

Any force that keeps object moving in a circle

$$F_c = m a_c^2 = m \frac{v^2}{r}$$

Not a type of force, just a description: can be caused by tension, gravity, etc.