Chapter 3: NEWTONIAN PHYSICS I

(How Things Move – Part of Mechanics)

Outline of today's class:

Few closing comments on atoms (ch. 2)
Quizzes related to ch. 2
Galileo, experimental method, pre-Newtonian ideas
Motion & concept of *inertia*
Velocity & acceleration
Some more quizzes
Falling objects (time permitting)

Worth remembering about atoms:

1)Small: ~10^{-10}m

2)Always in (temperature-dependent) motion

3)Mostly empty – are divisible/composite objects, with a tiny nucleus (~10^4 smaller) containing essentially all the mass, though

4)Electrically negatively charged electrons moving around an electrically positively charged nucleus (consisting of protons & neutrons)

5)Can bind to form molecules

6)Correct quantitative description requires Quantum Physics

Quiz # 1:

How many atoms in a molecule of $C_2H_6OH_2$?

(a) 9 (b) 11 (c) 12 (d) 10

Quiz # 2:

Chemical formula for sulfur dioxide?

(a) SO_2 (b) S_2O (c) SO

Quiz # 3:

Distance to the sun ("astronomical unit") is about 150 million km. How many meters in powers of ten?

(a) 1.5×10^{10} (b) 1.5×10^{12} (c) 1.5×10^{11} (d) 1.5×10^{-10}

Quiz # 4:

Assume a container with 10^{22} O_2 molecules, with an atomic weight of 10^{-26} kg for each oxygen atom. Total weight (in grams) of oxygen in container?

(a) 10^{-4}g (b) 2 g (c) 0.2 g (d) 0.01 g (e) 0.02 g

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Newtonian physics: cornerstone of "classical" physics, considered (with good justification) one of history's *greatest* intellectual achievements…..and yet, as discovered in the early 1900s (Einstein!), it is an approximation, albeit a very good one for many applications.

Why study Newtonian Physics?

1) Most practical devices (cars, trains, planes) are Newtonian.
2) Motions of planets & moons are Newtonian.
3) Philosophical differences between Newtonian and post-Newtonian worldview will be important later.

Let’s test intuition, conceptual understanding, and look for possible mis-conceptions:

Natural or *intrinsic* tendency of an object in motion is

a)to continue said motion

b)to slow down

c)to speed up

d)depends upon where the object is

Heavier objects will fall faster than light objects.

a)True

b)False

c)Depends upon where the objects are

Central idea of chapter 3: Law of Inertia, a profound and, as it turns out, surprising scientific idea.

Our intuition, pre-Galileo notions, Galileo's very clever experiments and reasoning: demos!
(drop book, ball, sheet of paper, crumpled paper, etc.
also shove/push objects, i.e. horizontal motion – air track)

So, what have we learned about the natural, *unforced* motion of objects once they're no longer held or pushed?

→ Heavier objects fall faster, moving objects come to rest or remain at rest……..really??

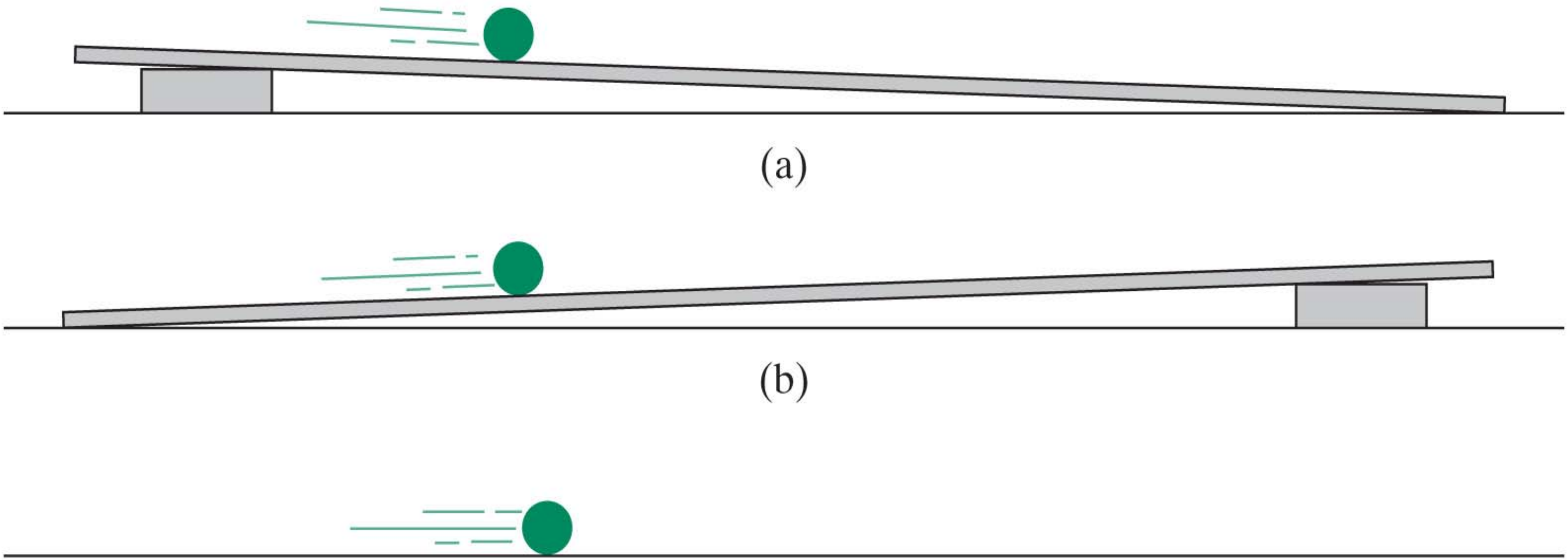
http://www.youtube.com/watch?v=5C5_dOEyAfk

(and drop small paper directly above larger book)

→ Friction and/or air resistance lead us astray!

Galileo’s crucial step: “idealized” experiment (at least mentally), i.e. neglect friction.

Brilliant reasoning:



(a)

(b)

(c)

Demos: air track & free fall in vacuum

Galileo & Descartes focused on tendency to keep moving rather than coming to rest – *"inertia"* (to become "mass" in the next chapter, not "weight"!)

Also useful to interpret inertia as resistance of an object to change its state of motion.

→ Table cloth pull & string breaker

Law of Inertia[3]

A body that is subject to no external influences (also called external forces) will stay at rest if it was at rest to begin with and will keep moving if it was moving to begin with; in the latter case, its motion will be in a straight line at an unchanging speed. In other words, all bodies have inertia.

(often called Newton's 1st law)

<u>Description of motion:</u>

Concepts of speed (s) & velocity (v) & acceleration (a)

s = d(istance) / t(ime)   - oh my God, an equation!

Distinguish instantaneous from average speed! (Every speed is really an average over some time interval – example: car speedometer.)

Important: v carries directional info (it’s a “vector”)

a(cceleration) is a subtle concept (and also a vector)!

a = *change* in v / time to make said *change*

Important: this physics definition for a includes *deceleration*&*change in direction of* v!

CONCEPT CHECK 6 Two bicyclists, both moving at 10 km/hr, pass each other on a straight road, one moving north and the other moving south. These bicyclists have (a) the same speeds and the same velocities; (b) different speeds and different velocities; (c) different speeds but the same velocities; (d) the same speeds but different velocities.

CONCEPT CHECK 8 Which of these have a high velocity and low acceleration? (a) A speeding bullet moving through air. (b) A race car just as it begins to "dig out" from rest. (c) A fast train as it moves around a long and gentle curve. (d) A fast car as it collides with a brick wall. (e) A golf ball at the instant it is struck by a fast-moving golf club.

CONCEPT CHECK 9 In the preceding question, which ones have a low velocity and high acceleration?

Emphasize again: difference between v and a. Can have v without a, a without v (at least instantaneously!) or both or neither.
More examples…..

Is circular motion with constant speed accelerated motion?

(a) yes (b) no

Problem 3: 3.8×10^8m to the moon. How long for a radar beam with s = 300,000 km/s (speed of light!) to get to the moon and back?

$s = d/t \rightarrow t = d/s = ?$

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$s = d/t \rightarrow t = d/s = 2 \times 3.8 \times 10^8 m / 3 \times 10^8 m/s = 2.5$ s

Important: make sure units work out correctly!
In this case meters divided by meters/second results in seconds, which is correct unit for time.

Quiz # 5:

Can you drive your car around the block at constant speed *and* constant velocity?

(a) yes (b) no

Quiz # 6:

What's the overall average speed (in km/hr) of a jogger who jogs 3 km in 15 min and then the next 2 km also in 15 min?

(a) 5 km/hr (b) 7.5 km/hr (c) 20 km/hr (d) 10 km/hr

Quiz # 7:

Light (s = 300,000 km/s) takes about 8 min to the sun. How far to the sun, approximately (calculate in your head!)?

(a) 10^8 km (b) 1.5×10^7 km (c) 1.5×10^8 km