Portrait by Justus Susterman, 1636

"If I shall have sufficient strength to improve and amplify what was written and published by me up to now about motion by adding some little speculations, and in particular those relating to the force of percussion, in the investigation of which I have consumed hundreds and thousands of hours, and finally reduced this to very easy explanation, so that people can understand it in less than half an hour of time."

Galileo Galilei (1564-1642)
in a letter to Giovanni Battista Baliani

PHY100 - Some Reminders

- Homepage
  - → http://www.atmosp.physics.utoronto.ca /people/strong/phy100/phy100.html
- Portal/Blackboard
  - → I have activated the course on the Portal, but will be using the external homepage to provide course content
- Textbook
  - → *Physics: Concepts and Connections*, Fifth Edition, Art Hobson, Pearson Education (2010) – in the Bookstore
- Tutorials
  - → Begin next week: January 15, 16, 17
  - → There will be a weekly quiz, starting next week!
- Office hours: 3-4 PM Tuesdays and Thursdays

Tutorials – One per Week

- Six groups / four time slots to choose from:
  - → TUT 0101 12-1 Tuesday (room RW142)
  - → TUT 0102 12-1 Tuesday (room LM155)
  - → TUT 0201 12-1 Wednesday (room SS2128)
  - → TUT 0301 1-2 Wednesday (room RW142)
  - → TUT 0401 12-1 Thursday (room RW142)
  - → TUT 0402 12-1 Thursday (room UC177)
- Tutorial groups are capped at 33 students
- Last day to register on ROSI is January 20
- Please enroll before tutorials start on Tuesday, January 15
- I will post room and TA assignments by January 15

Current Assignments ...

For today:

- Read Sections 3.2, 3.3, 3.4, 3.5

For Lecture 3:

- Read Sections 4.1, 4.2, 4.3

Suggested Conceptual Exercises:

- Chapter 1: 23, 25, 27, 33, 35
- Chapter 3: 1, 3, 7, 9, 11, 19, 21, 25

Enroll in tutorial section by Tuesday, Jan 15

- Go to your first tutorials next week

Review of Lecture 1

- Introduced the course
- Discussed "What Is Science?"
  - → combines theory with observations
  - → addresses "How do we know?"
- Described the scientific process
- Started to examine how things move
- Introduced Aristotle's theories of motion
  - → natural, violent, and celestial motion
  - → consistent with our intuition, but wrong!
  - → dropped and pushed lots of objects

Plan for Lecture 2

Textbook, Sections 3.2, 3.3, 3.4, 3.5

- Galileo's Law of Falling
- Galileo's thought experiment: inclined plane
- The Law of Inertia
- Kinematics: describing motion
  - → distance and time
  - → speed
  - → velocity
  - → acceleration

Recap: Aristotle on Motion

1. **Raised objects fall toward Earth's surface (natural motion)**
   Observations: dropped book, paper, balls
2. **Heavier objects fall faster (have more of element Earth, so seek ground more strongly)**
   Observations: book fell faster than sheet of paper
3. **Moving objects come to rest (need violent motion, a push or pull, to move)**
   Observations: slid book and rough ball across the table – both came rapidly to rest
4. **Objects at rest remain at rest**
   Observations: book and ball at rest stay there

But …

… more experiments showed that

- A flat piece of paper fell slower than a crumpled one, despite having the same mass
- A small piece of paper dropped just above the book fell at a similar speed
- Balls of different masses fell at similar speeds
- A smooth ball rolled much further along the table

Galileo's Law of Falling

- Galileo did detailed studies of falling and rolling objects, and formulated his Law of Falling:
  If air resistance is negligible, then any two objects that are dropped together will fall together, regardless of their weights and their shapes, and regardless of the substances of which they are made.

Apollo 15 Hammer and Feather Experiment

NASA Astronaut Dave Scott demonstrates gravity on the Moon
http://www.hq.nasa.gov/alsj/a15/video15.html#closeout3

Galileo's Thought Experiment

- Let's throw a ball across the room.
  - → Once it leaves my hand, what keeps it moving?
  - → Aristotle says there must be a constant force to keep it in motion.
- Galileo's thought experiment:
  Let a ball roll down an incline; it will speed up. Let it roll up the incline; it will slow down. In between, on a perfectly flat surface with no friction, the ball will keep rolling at a constant speed forever.

Galileo's Method

- Experimentation, to test a specific hypothesis
- Idealization, to eliminate side effects
- Consider only one question at a time
- Quantitative methods: precise measurement

The Law of Inertia


René Descartes: portrait by Jan Baptist Weenix, 1647-1649

Descartes (1596-1650) imagined turning off air resistance, friction, and gravity.

The Law of Inertia (also Newton's 1st Law):
A body that is subject to no external influences (also called external forces) will:

1) stay at rest if it was at rest to begin with

2) keep moving in a straight line at constant speed if it was moving to begin with.

In other words, all bodies have inertia.

Describing Motion

- Distance and Time
- Speed and Velocity
- Acceleration
- Using graphs to describe motion

Distance and Time

- We need two ideas to describe motion: velocity and acceleration.
- We define these in terms of two fundamental and directly measurable quantities: distance and time, measured by meter sticks and clocks.

- distance - units of length - meters (m)
- time - units of time - seconds (s)

Speed and Velocity

- Speed is the distance an object moves divided by the time it takes to move.
  - → Suppose you drive 100 km in one hour. Your average speed would be 100 km/h.
  - → Your instantaneous speed is your speed at one particular moment (over a short time interval) - this is what your speedometer measures.
- Velocity means speed and direction.
  - → If I am driving 100 km/h, that is my speed
  - → If I am driving 100 km/h north, that is my velocity

Acceleration

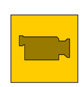
- The Law of Inertia tells us that an undisturbed object will keep moving with a constant velocity.
- If an object's velocity is changing, it is accelerating.
- Acceleration is the rate of change of velocity:

  acceleration = (change in velocity) / (time to make the change)
- Acceleration is measured in (m/s)/s, or m/s^2.

Using Graphs to Describe Motion

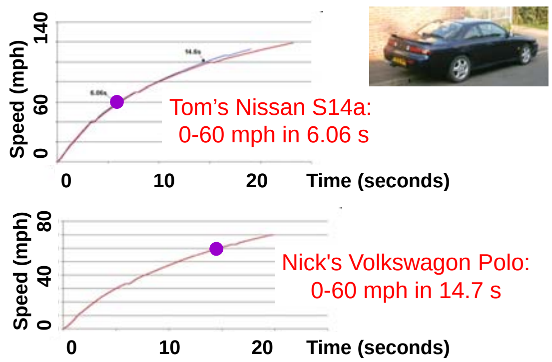
Flash animation

http://faraday.physics.utoronto.ca/PVB/Harrison/Flash/ClassMechanics/MotionDiagram/MotionDiagram.html



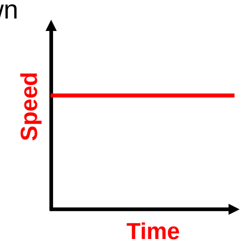
Obsolete link

http://tom.marshall.tripod.com/ap-22.htm



This Figure Shows the Speed Versus Time for a Car

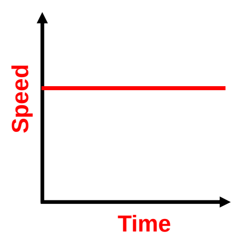
1. The car is speeding up
2. The car is slowing down
3. The car is moving at constant speed



This Figure Shows the Speed Versus Time for a Car

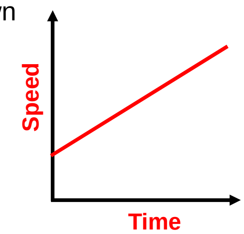
The acceleration of the car is:

1. Zero
2. Positive
3. Negative



This Figure Also Shows the Speed Versus Time for a Car

1. The car is speeding up
2. The car is slowing down
3. The car is moving at constant speed



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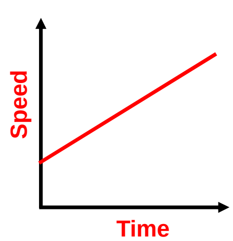

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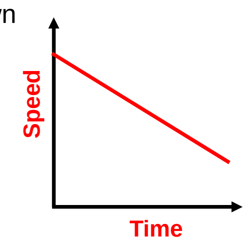

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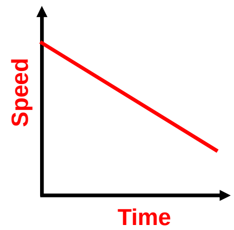
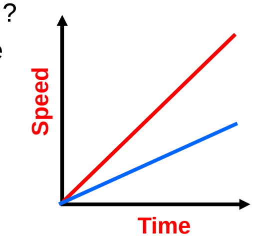


This Figure Shows the Speed Versus Time for Two Cars

Which car has the greater acceleration?

1. They have the same acceleration
2. The car represented by the red line
3. The car represented by the blue line



Concept Check 7

During a trip, a car executes several kinds of motion. In which of the following is the car accelerated?

(a) Moving along a straight, level road at a steady 70 km/hr.

(b) Moving along a straight, level road while slowing down from 70 km/hr to 50 km/hr.

(c) Rounding a curve at a steady 50 km/hr.

(d) Moving uphill along a straight incline at a steady 50 km/hr.

(e) Rounding the top of a hill at a steady 50 km/hr.

(f) Starting up from rest along a straight, level road.