Chapters 3 & 4: Continuation of Newtonian Physics

(Mechanics) – how & why things move

Outline of today's class (apart from quizzes):

Briefly re-visit inertia

(Free) falling objects & acceleration due to gravity

Force, mass, weight

$F = m \times a$ (force = mass × acceleration, a.k.a. Newton's 2nd Law of Motion)

Outlook on Newton's 3rd Law & Momentum (time permitting)

Repeat a couple inertia demos…….discussion, questions?

Law of *inertia* in concise form:

$F_{net,\ external} = 0$ ➔ v = const. (or a = 0, of course)

No net external force on an object implies constant velocity or no acceleration for the object.

"*If no (net, external)* ***force*** *exists, the motion persists!*"

(Units of a: m/s^2 (meters per second squared) - clear?)

Quiz # 8:

Which *outside* influences act on an object while it falls to the ground (through the air)?

(a) There are no outside influences
(b) Inertia & Gravity
(c) Only Gravity
(d) Air Resistance & Gravity
(e) Air Resistance & Inertia

Quiz # 9:

A car travels 8 km in 15 minutes, while a bicyclist races for 1 minute at 30 km/hr. The one with the higher average speed is (a) the car; (b) the bicyclist; (c) they have the same speed.

Quiz # 10:

A car turns a corner at a steady 100 km/hr. Its acceleration is (a) zero; (b) non-zero; (c) not enough info to answer.

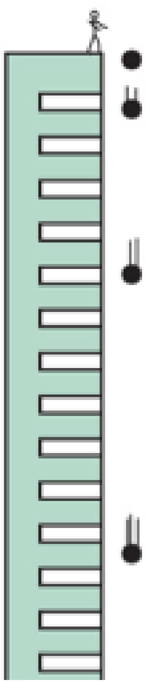
Quiz # 11:

Car 1 goes from 0 to 30 km/hr. Later car 2 goes from 0 to 60 km/hr.

(a) Car 1 had the greater acceleration.
(b) Car 2 had the greater acceleration.
(c) Not enough info to answer.

Let's re-visit hammer & feather on the moon:

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



Time	Approx-imate distance	Approx-imate speed
0 s	0 m	0 m/s
1 s	5 m	10 m/s
2 s	20 m	20 m/s
3 s	45 m	30 m/s

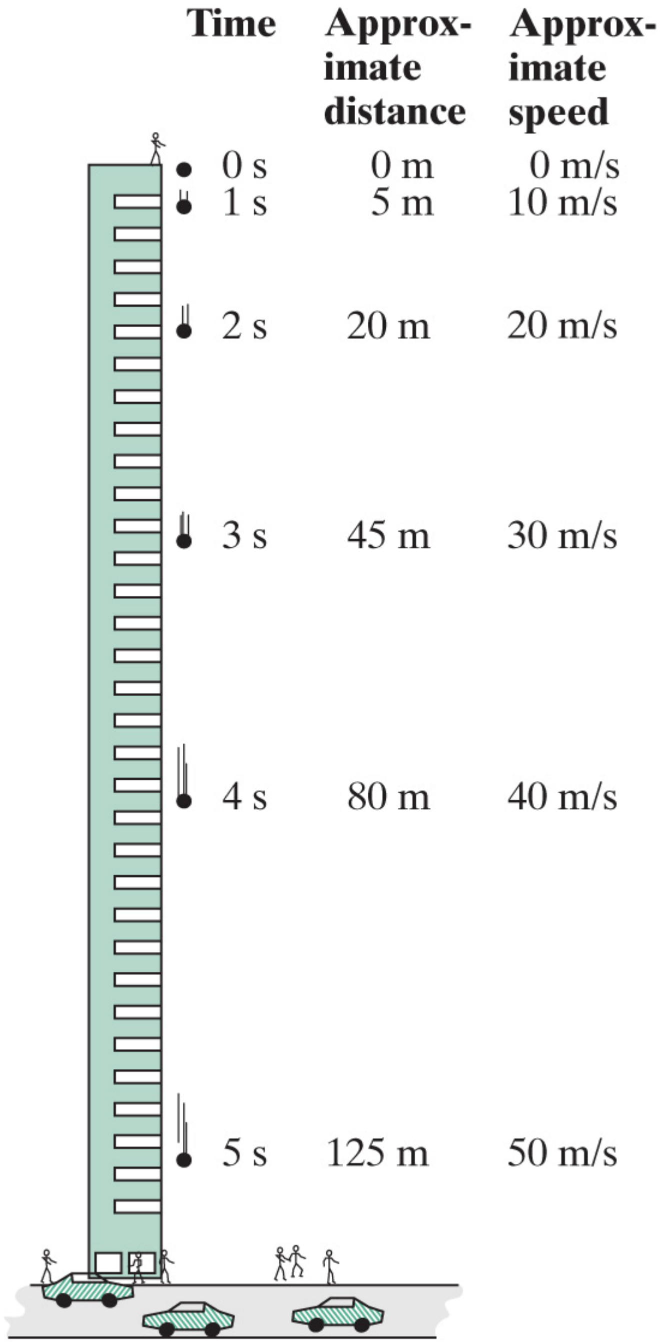
<u>Falling objects, free fall on earth:</u>

clearly downward acceleration, right?

Guess speed at t = 4 s

Is a constant?

a = ?



$a = 10\ m/s^2$ (actually more like $9.8\ m/s^2$, called "g", the acceleration due to gravity)

Freely falling objects on earth fall with this acceleration g.

Quiz # 12:

For a freely falling object

(a) the acceleration keeps increasing

(b) the total distance fallen keeps increasing, but not the distance covered during each second

(c) the change in speed during each second keeps increasing

(d) all of the following keep increasing: the total distance fallen, the distance covered during each second, and the speed

Chapters 4: More on Newton's Laws – why things move as they do……"Forces"!

1687: Publication of Newton's "Principia" – an unparalleled and profound expansion and unification of our understanding of nature.

What causes a change in motion, an acceleration?
→ "force" F – *always exerted by one object on another. Forces do not exist by themselves.*

Examples encountered so far: push, pull, friction, air resistance (contact forces). But also non-contact forces: gravitational force (ch. 5), electromagnetic force (ch. 8)
(demo)

Newton's 2nd Law (Law of Motion):

Experimental result: a is proportional to F, and inversely proportional to the "amount of inertia", called mass m.

Using proper units: $a = F/m$ or $F = ma$

(a in m/s^2, m in kg, resulting F in "Newtons" N, i.e. $1\ N = 1\ kg\ m/s^2$)

Demo: push on table → why doesn't table move? Other demos, air track, magnets,…

F in $F = ma$ has to be F_{net}! (F is a vector, as is a, but not m)

CONCEPT CHECK 3 A slow car moves at a steady 10 km/hr down a straight highway while another car zooms past at a steady 120 km/hr. Which car has the greater net force on it? (a) The slower one. (b) The faster one. (c) The one having the greater air resistance and rolling resistance. (d) None of the above.

Answer: d (neither car is accelerating, $F_{net} = 0$)

Keep in mind the "big picture": *Forces cause accelerations*

$F_{individual} \rightarrow F_{net} \rightarrow$ acceleration ($\rightarrow$ kinematics)

Examples: C.E. 6, 8, 12

6. If you exert a force on an object and then exert three times as strong a force on the same object, what (if anything) can you say about the object's acceleration during the exertion of each force? Assume no other force acting on the object.

A: $a_2 = 3a_1$ if $F_2 = 3F_1$

8. An object moves with unchanging speed in a straight line. Does it then have no forces acting on it? Explain. Does it have no net force acting on it?

A: Could have forces acting on it, provided $F_{net} = 0$ (car!). Indeed, no F_{net} though, because $a = 0$.

12. A car starts up from rest, moving along a straight highway with an acceleration of 1 m/s^2. A second car comes racing past at a steady 120 km/hr. Which car has the larger net force acting on it?

A: First car – F_{net} needed for a.

Quiz # 13:

To achieve $a = 50$ m/s^2 for a 0.5 kg baseball, a pitcher must exert a force of

(a) 25 N (b) 10 N (c) 20 N (d) 100 N

Weight: different from mass!

Weight = gravitational force on an object(unit?)

(Demo: masses on a calibrated spring)

Consider a 1 kg mass: Same mass on moon? Same weight?

C.E. 24: Rather have hunk of gold whose mass is 1 kg on moon or 1 kg on earth?

In contrast to C.E. 23: …whose weight is 1 N on moon or 1 N on earth?

Quiz # 14:

You throw an apple (weight = 2 N) upward. Just after you threw it, while it's still moving upward, the strength and direction of the net force (ignore air resistance) on the apple is

(a) 2 N upward (b) 2 N downward (c) neither (a) nor (b)