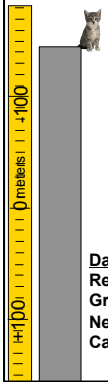
Skydiving and car crashes



If a cat jumps from a 10 story building is it more or less likely to survive than you ??

It's not the speed that is a problem it's the stopping

Day 5:
Reading quiz
Gravity (cont)
Net forces: Terminal velocity
Car crashes

Reminders:
Homework 3 online
Midterm next Thursday
Don't forget to 'submit' your HW

Reading quiz

Which required larger forces:
a) Lifting 50 1kg bricks all at once
b) Lifting 50 1kg one at a time
c) They require the same force

Which of the following is **not true** in riding up in an elevator?

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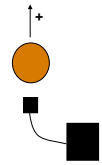
Summary

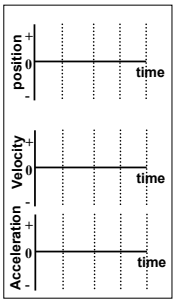
Last time:
- Introduced forces
- $\underline{F}_{net} = m\underline{a}$
- $F_{gravity} = mg$

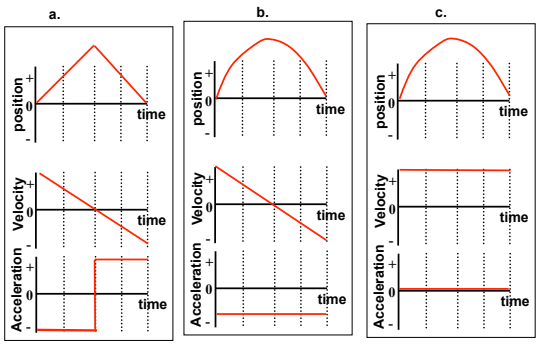
Today: More on forces
- More on gravity
- Net forces : Terminal velocity
- Car crashes

Question: Relating position, velocity and acceleration

Toss a basketball straight up in air with initial velocity v_0
Plot position, velocity and acceleration vs time.



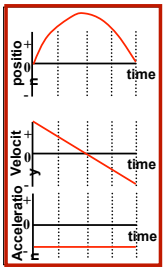




d. none of the above.

Would these plots for a, v and x change if I used a medicine ball instead of a basketball (same initial velocity)?
a. No
b. Yes

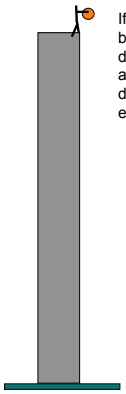
b.



Would these plots for a, v and x change if I used a medicine ball instead of a basketball?

a. No

b. Yes

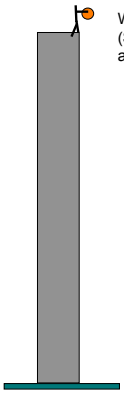


If I drop the basketball off a tall building, what will the ball's the velocity be after 0.5 s (define up as positive direction):

a. 1 m/s b. 9.8 m/s c. -9.8 m/s

d. Not enough information given to determine

e. -4.9 m/s



What will the position of the ball be after 0.5s?
(Set the position of my hands to be the origin and set up as the positive direction)

a) 2.5m
b) - 2.5m
c) 4.9 m
d) - 4.9 m
e) None of these

Common confusion: Weight and Mass…….

Mass is a measure of how much stuff an object has
Units: kg (old fashioned units = lb)

$Force_{net}$ = mass X acceleration
Units: Newton (N).
1 kg X 1 m/s^2 = 1N

Weight = force of gravity on an object of mass m
Measured in N NOT kg or lb
kg and lb are units of mass

The acceleration due to gravity on the Moon is less than it is on Earth.
Suppose
m_E = your mass on Earth
m_M = your mass on the Moon
w_E = your weight on Earth
w_M = your weight on the Moon.

Which statement is correct?

a) $m_E > m_M$, $w_E > w_M$
b) $m_E = m_M$, $w_E > w_M$
c) $m_E = m_M$, $w_E = w_M$
d) $m_E > m_M$, $w_E = w_M$
e) None of these

The acceleration due to gravity on the Moon is less than it is on Earth.
Suppose
m_E = your mass on Earth
m_M = your mass on the Moon
w_E = your weight on Earth
w_M = your weight on the Moon.

Which statement is correct?

a) $m_E > m_M$, $w_E > w_M$
b) $m_E = m_M$, $w_E > w_M$
c) $m_E = m_M$, $w_E = w_M$
d) $m_E > m_M$, $w_E = w_M$
e) None of these

Net force

The little car is at rest on a horizontal track. Which way does the force on the car due to *gravity* point?

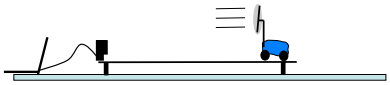
A) Left
B) Right
C) Up
D) Down
E) None of these

Net force

The little car is at rest on a horizontal track. Which way does the support (or normal) force on the car due to *the track* point?

A) Left
B) Right
C) Up
D) Down
E) None of these

The little car is on a horizontal track, and blown by a fan. Which way does the net force point?

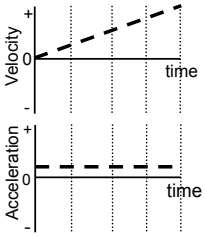


A) Left
B) Right
C) Up
D) Down
E) None of these

Free body (force) diagram

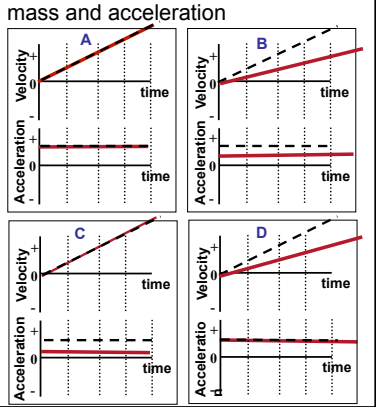
Force, mass and acceleration

The car is pushed by the fan with a **constant force**. Its velocity and acceleration are as shown below. Now double the mass of the car. Sketch what the new velocity and acceleration curves look like.



Force, mass and acceleration

Dashed curves are the velocity and acceleration for a single car. Which red curves represent car plus weight?



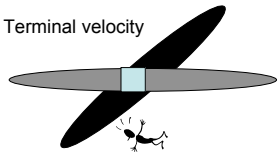
Confusing language

Regular people: Velocity: how fast you are going = speed.
Physicists: Velocity: the speed and direction of motion.

Regular people: acceleration: speeding up.
Physicists: acceleration: the rate of speeding up or slowing down or changing direction of motion.

Regular people: kg: a weight= 2.2 pounds,
Physicists: kg: a mass. On earth this mass has a weight of 1kg x 9.8 m/s^2 = 9.8 N

Terminal velocity



A 100 kg man steps out of a plane. Immediately after he leaves the plane:

a. The force of gravity on the man is 100 kg downwards, the net force on him is 100kg downwards, and his acceleration is 9.8 m/s^2 downwards.
b. The force of gravity on the man is 100 kg downwards, his net force is 0, and his acceleration is 0 m/s^2.
c. The force of gravity on the man is 980 N downwards, the net force on him is 980 N downwards, and his acceleration is 9.8 m/s^2 downwards.
d. The force of gravity on the man is 980 N, the net force on the man is 0 N, and his velocity increases until it is 9.8 m/s downwards and then stops increasing.
e. The force of gravity on the man is 980 N, the net force on the man is 0 N, and his acceleration is 9.8 m/s^2 downwards.

Terminal velocity

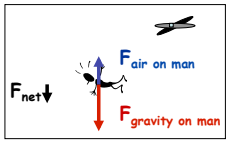
After the man falls for some time, he finds that he is falling at a constant velocity. At this time…

a. The force of gravity on the man is 100 kg downwards, the net force on him is 100kg downwards, and his acceleration is 9.8 m/s^2 downwards.
b. The force of gravity on the man is 100 kg downwards, his net force is 0, and his acceleration is 0 m/s^2.
c. The force of gravity on the man is 980 N downwards, the net force on him is 980 N downwards, and his acceleration is 9.8 m/s^2 downwards.

d. The force of gravity on the man is 0 N, the net force on the man is 0 N, and his acceleration is 0 m/s^2.
e. The force of gravity on the man is 980 N, the net force on the man is 0 N, and his acceleration is 0 m/s^2.

Terminal velocity

F_{air} increases with velocity:
⇒ Before reaching terminal velocity, forces don't quite cancel.



- F_{net} = sum of all forces
  → In this case, $F_{net} = F_{gravity\ on\ man} + F_{air\ on\ man} \neq 0$
- F_{net} = mass x acceleration

- Since F_{net} is not zero, tells us man will accelerate!
- Acceleration will be smaller than 9.8 m/s^2 because net force is smaller than force of gravity on man.
- Velocity will be changing ! Speeding up in downwards direction

Terminal velocity numbers

Humans: 120mph.
Reached after falling 50 stories
Falls are fatal from 15 to 38 mph

Cats: 60mph.
Reached after falling about 5 stories
Can survive a terminal velocity fall

Why Terminal Velocity lower for cats than humans?
- **Smaller mass ⇒ force of gravity smaller**
- **More hair ⇒ Air resistance increases rapidly with increasing velocity**

Smaller animals: Mice, spiders etc
Even smaller terminal velocity
Very likely to survive a terminal velocity fall

Large raindrops ~ 20 mph