Phys 131 2024

Lecture 4

Tues: Discussion / quiz

Ex: 38, 39, 41, 43, 44, 46

Weds: Warm Up 2 D2L due by 9am

Velocity

The flow of ideas about velocity is:

CONCEPTUAL IDEA

Velocity ~ rate of change of position

MATHEMATICAL DEFINITION

Observe motion from $t \to t + \Delta t$ and determine change in position, Δx. Then velocity is

$$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$$

→ Speed = magnitude of velocity

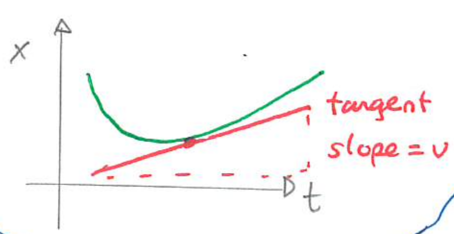
$$s = |v|$$

CALCULATION / COMPUTATION

Given position versus time

Get velocity via

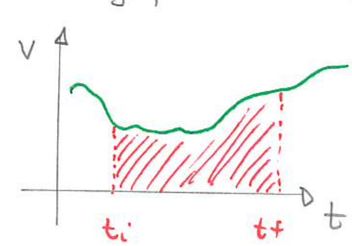
1) calculus → differentiation
2) from graph of x vs t



Given velocity versus time

Get change in position via

1) calculus → integration.
2) from graph of v vs t



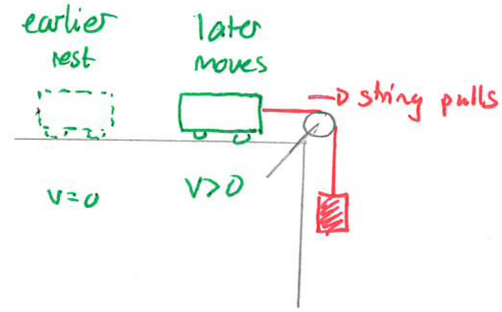
Δx = area between graph and t-axis

$$x_f = x_i + \Delta x$$

Acceleration

The crucial questions in classical physics involve interactions between objects.

We can consider a cart on a track connected to a suspended object. At an initial moment the cart is at rest. It will subsequently move and thus its velocity changed. It continues to speed up as the string pulls. We then introduce the concept



> acceleration ~ rate at which velocity changes

DEMO: PhET Moving Man – Charts tab

* Initial $x = 0$
  $v = -6$
  $a = 2$

* Observe – apparent motion
  – graph of v vs t

* Three phases – start to turn
  – just before turn to just after
  – just after turn to return.

The graph that velocity is constantly changing. This means that the object will have non-zero acceleration

1) while its speed changes (increases or decreases)

2) while its direction of motion changes.

A preliminary definition that captures all of these is:

Observe the object at two instants. Then the average acceleration of the object over the interval from t_i to t_f is

	initial earlier	final later
time	t_i	t_f
velocity	v_i	v_f

$$a_{avg} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

Units: m/s^2

Fundamental Mechanics: Group Exercise 1

26 August 2024

Names: ____________________ ____________________ ____________________

____________________ ____________________

1 Rotating object

Take a rectangular object with three sides of different lengths: a phone is a good example. Try to flip the phone in such a way that it rotates and does not "tumble." Try this for three distinct axes. Is it easier to to this about some axes rather than others? Have you ever noticed this before? Where? *The instructor will provide some assistance.*

2 Moving man animation

An animation shows a man moving horizontally. The table provides data for the positions and velocities of the man at various times.

Time	Position	Velocity
0.0 s	4.0 m	−6.0 m/s
1.0 s	−0.5 m	−3.0 m/s
2.0 s	−2.0 m	0.0 m/s
3.0 s	−0.5 m	3.0 m/s
4.0 s	4.0 m	6.0 m/s

a) Does the velocity of the man stay constant, increase or decrease during the period from 2.0 s to 4.0 s? By how much does the man's velocity increase every second?

b) Does the velocity of the man stay constant, increase or decrease during the period from 0.0 s to 2.0 s? By how much does the man's velocity increase every second?

c) Does the man have zero or non-zero acceleration from 1.0 s to 3.0 s?

d) Determine the average acceleration of the man from 0.0 s to 2.0 s.

e) Determine the average acceleration of the man from 2.0 s to 4.0 s.

f) Determine the average acceleration of the man from 1.0 s to 3.0 s.

g) Is there any clear correlation between acceleration and position?

h) If the speed of an object is larger, does this automatically mean that the acceleration is larger?

a) It increases by 3.0m/s every second

b) It increases by 3.0m/s every second

c) Velocity changes ⇒ acceleration ≠ 0

d) $a_{avg} = \frac{v_f - v_i}{t_f - t_i} = \frac{0.0m/s - (-6.0m/s)}{2.0s}$

$= 3.0m/s^2$

e) $a_{avg} = \frac{v_f - v_i}{t_f - t_i} = \frac{6.0m/s - 3.0m/s}{2.0s}$

$= 3.0m/s^2$

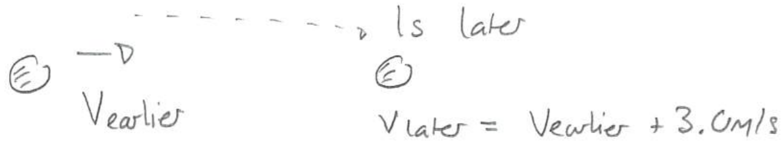
f) $a_{avg} = \frac{v_f - v_i}{t_f - t_i} = \frac{3.0m/s - (-3.0m/s)}{2.0s}$

$= 3.0m/s^2$

g) No

h) No, in this example $a = 3.0m/s^2$ for many different speeds

In this example the acceleration is $3.0 m/s^2$. This means the velocity increases by 3.0 m/s every second. Schematically



Notes:

1) acceleration does not describe velocity.

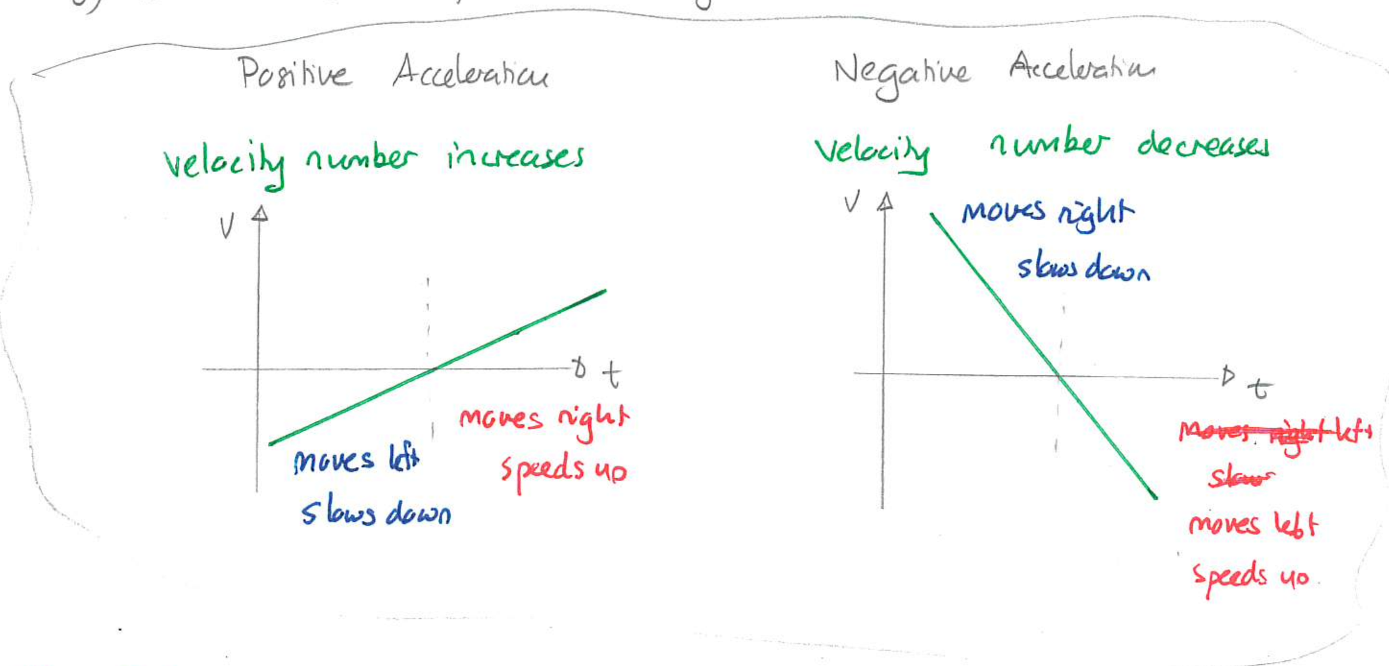
   e.g. same acceleration → many different velocities for exercise

   an object can have a larger acceleration and a smaller speed.

Quiz 1 20% — 80% ⇝ 10% → 90%

2) acceleration is not immediately connected to speed. The object's speed could be the same at the beginning as at the end of a period but it can have non-zero acceleration if its direction of motion changes

3) acceleration can be positive or negative



Quiz ~~3~~ 2

Quiz 3

Generally

Acceleration describes how velocity (number) changes over time.

Constant acceleration

A special case of motion is that where acceleration is constant.

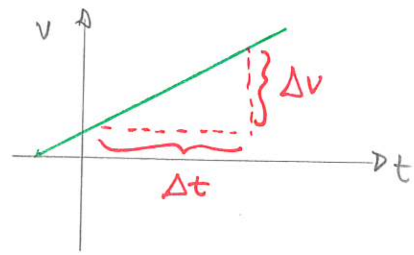
For motion with constant acceleration

$$a = \frac{\Delta v}{\Delta t}$$

exactly. and

$$\Delta v = a \Delta t$$

→ Graph of v vs t is a straight line with slope = accel



CONSTANT ACCELERATION