Mon: Warm Up 5 due by 9am

Tues: Review Test 1

Thurs: ~~Test~~ 1 - covers
Class exam

* lectures 1→12
* HW 1→4
* Discussions 1-4

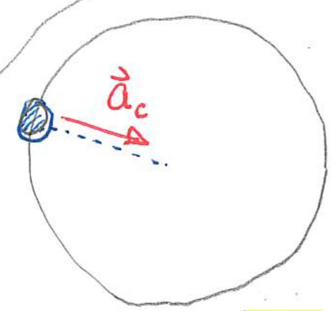
- see 2024 Class exam 1
  2023 " " 1

Uniform circular motion

Uniform circular motion is motion where:

1) the object moves in a circle
2) the object moves with constant speed

The standard kinematics of velocity and acceleration vectors gives that:



1) the acceleration is radially inward (points toward the center)
2) has magnitude

$$a_c = \frac{V^2}{r}$$ centripetal acceleration

Quiz 1 40% - 80%

137 Acceleration on Earth's surface

People stand on Earth's surface and are at rest *relative to Earth.* Earth has a radius of 6.4×10^3 km and spins about its poles at a rate of one revolution every 24 hrs. *(131Sp2025)*

a) Determine the acceleration of a person at Earth's equator.

b) Another person stands at a location much closer to the North pole. Is this person's acceleration the same as, larger than or smaller than that of a person at the equator? Explain your answer.

Answer: a) The person orbits in a circle with radius R_E = radius of Earth

Let T be the time taken for one orbit.

Then $a = \frac{v^2}{R_E}$ and $v = \frac{2\pi R_E}{T}$

give $a = \frac{(2\pi R_E/T)^2}{R_E} = \frac{4\pi^2 R_E^2/T^2}{R_E} \Rightarrow a = \frac{4\pi^2 R_E}{T^2}$

Here $T = 24\,\text{hr} \times 60\,\text{min/hr} \times 60\,\text{s/min} = 86400\,\text{s}$

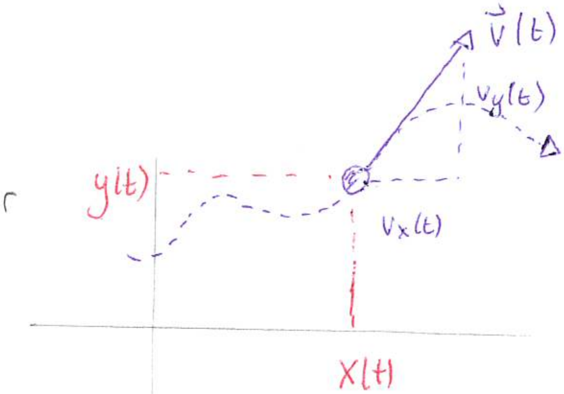
$$a = \frac{4\pi^2\, 6.4\times10^6\,\text{m}}{(86400\,\text{s})^2} = 0.034\,\text{m/s}^2$$

b) the person orbits in a circle with radius $r < R_E$. The same derivation would give

$$a = \frac{4\pi^2 r}{T^2}$$

and T is the same. Thus a would be less

Classical kinematics



Classical kinematics is a complete framework for describing position, velocity and acceleration

Position is described by coordinates

$x(t)$, $y(t)$

and these can be combined into a position vector

$$\vec{r}(t) = x(t)\,\hat{i} + y(t)\,\hat{j}$$

differentiate

Velocity ~ rate of change of position

$$\vec{v} = \lim_{\Delta t \to 0} \frac{\Delta \vec{r}}{\Delta t} \Rightarrow \vec{v} = v_x \hat{i} + v_y \hat{j}$$

where

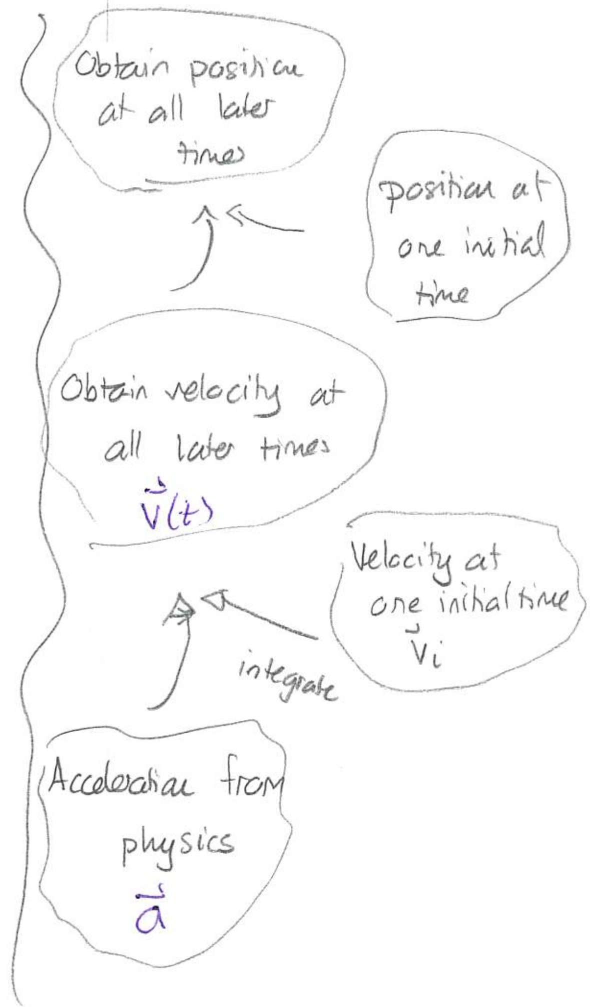
$$v_x = \frac{dx}{dt} \qquad v_y = \frac{dy}{dt}$$

differentiate

Acceleration ~ rate of change of velocity

$$\vec{a} = \lim_{\Delta t \to 0} \frac{\Delta \vec{v}}{\Delta t} \Rightarrow \vec{a} = a_x \hat{i} + a_y \hat{j}$$

$$a_x = \frac{dv_x}{dt} \qquad a_y = \frac{dv_y}{dt}$$

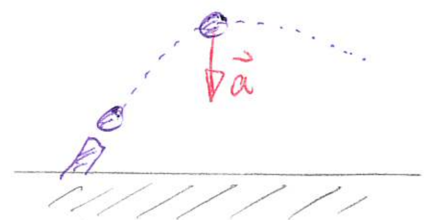


Physics normally provides the acceleration.
so the reverse process happens

Dynamics

Kinematics provides the language for describing how motion occurs. However, it does not describe why particular motion occurs. We still need to address <u>why</u> particular motion occurs

DEMO: PhET Projectile Motion
– show acceleration vector



For a projectile launched near Earth's surface observations show:

* acceleration is constant
* $\vec{a} = -9.8\,m/s^2\,\hat{j}$

But we can ask

* "Why is the acceleration constant?"
* "Is there some fundamental physics that predicts that the acceleration should be constant?"

Classical physics will provide a scheme for answering such questions:

Ball — [Pick an object of interest]

Earth, air — [Identify all other objects that interact with object of interest.]

→ Dynamics → [Interactions result in acceleration, Newton's Laws predict the <u>acceleration</u>.]

→ Kinematics → [Acceleration describes how <u>velocity</u> <u>changes</u>]

→ [Velocity describes how <u>position</u> <u>changes</u>]

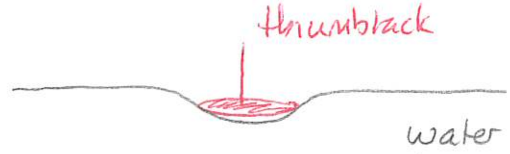
We will see that

Interactions determine acceleration ⇒ interactions determine how <u>velocity changes</u>

We will see that interactions do NOT determine why an object moves or what an object's velocity is.

Forces

We will use the concept of forces to describe the interactions between objects



DEMO: Cheerios effect video

Consider a thumbtack floating on the surface of the water.

The thumbtack interacts with the water. The scheme is:

(Identify object of interest) Thumbtack

(Identify another object that interacts with the object of interest) Water

(Specify a force that describes the interaction. This is a vector with
1) magnitude = strength of push/pull in interaction
2) direction = direction of push/pull in interaction)

We will say

(Object exerts a (type of) force on object of interest)

↑ Another object

e.g. Water exerts a surface tension force on thumbtack.

← different objects →

Forces and motion

Having specified the forces on an object we ask how they affect the motion of an object.

DEMO: PHET Forces in One Dimension → Friction ✗ Vectors ✗

Set force to constant – observe motion

– Turn force on and then off

Quiz 2

The animation suggests

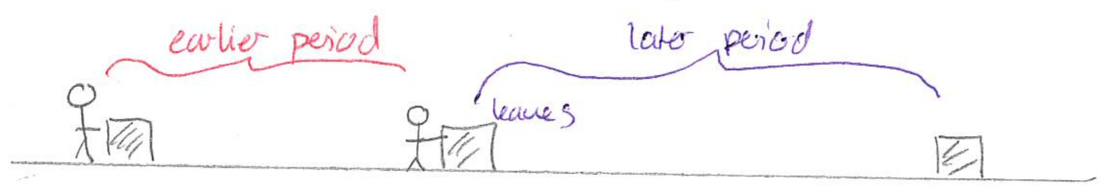
An object can move even if no force acts on it ⇝ Force is not essential to motion.

and

A force tends to change the state of motion of an object

Quiz 3

We can think of the motion as occuring in periods



- person pushes constantly
- person exerts a force on crate
- crate's motion changes

- person does not push on crate
- no force on crate
- ~~sto~~ crate's motion does not change

We only consider forces during the interval when the forces are acting. They are irrelevant before and after.