Lecture 12

Mon: Warm Up 5 (D2L) SPS Noon

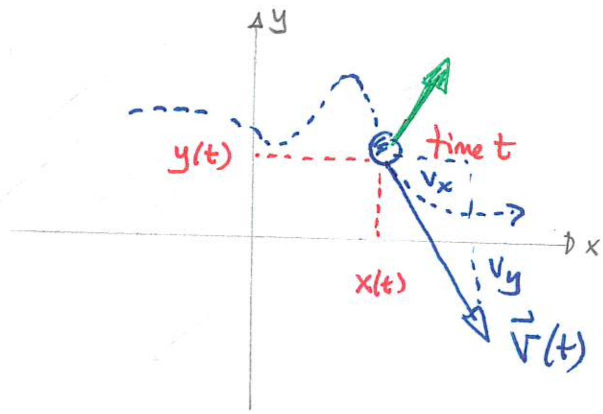
Tues:

Weds: Review

Fri: Exam Covers Classes 1 → 11

Classical kinematics

The framework of classical kinematics is as follows:



Position described by co-ordinates $x(t), y(t)$ and position vector $\vec{r} = x(t)\,\hat{\imath} + y(t)\,\hat{\jmath}$

→ (differentiate)

Velocity is rate of change of position

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

$\vec{v} = v_x\hat{\imath} + v_y\hat{\jmath}$

→ (differentiate)

Acceleration is rate of change of velocity

$\vec{a} = \frac{d\vec{v}}{dt}$ $a_x = \frac{dv_x}{dt}$ $a_y = \frac{dv_y}{dt}$

$\vec{a} = a_x\hat{\imath} + a_y\hat{\jmath}$

Physics often follows the reverse direction

Physics gives acceleration $\vec{a}$ at all times

Known velocity at one instant $\vec{v}_i$

→ (integrate)

Obtain velocity at all later times $\vec{v}(t)$

Known position at one moment $\vec{r}_i$

→ (integrate)

Obtain position at all later times

If acceleration is constant

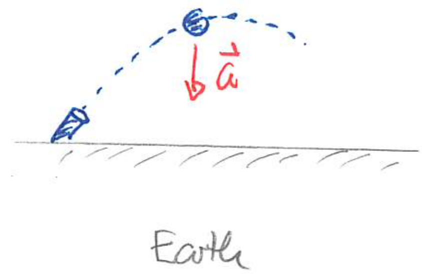
a_x, a_y constant → $v_{fx} = v_{ix} + a_x\Delta t$

$v_{fy} = v_{iy} + a_y\Delta t$

→ $x_f = x_i + v_{ix}\Delta t + \frac{1}{2}a_x\Delta t^2$

Dynamics

Kinematics provides the language of how motion occurs. We need to address questions of why particular motion occurs



DEMO: PhET Projectile motion
– Vectors Tab

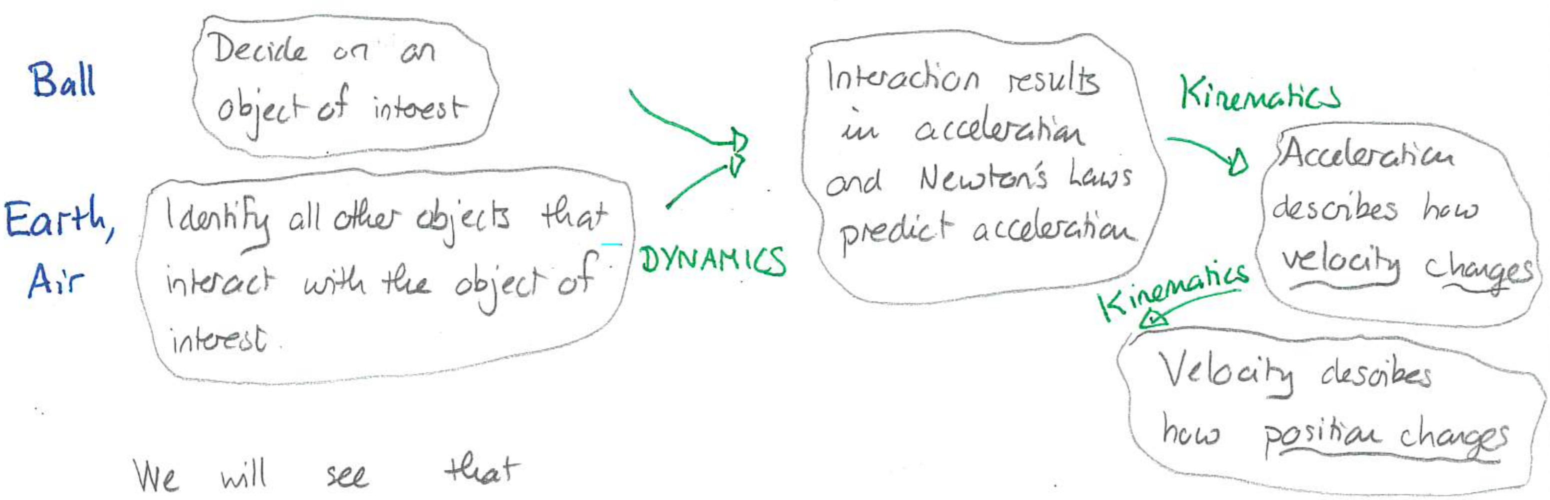
For example, consider a projectile launched near Earth's surface. We know

* the acceleration is constant
* $\vec{a} = -9.80\,m/s^2\,\hat{j}$

We seek to address

* "Why is the acceleration constant?"
* "Is there some fundamental physics involving the Earth that allows us to predict the acceleration?"

Classical physics can address such questions. The scheme will be



We will see that

Classical physics CAN answer

* how velocity changes
* what the acceleration is
* how state of motion changes

Classical physics CANNOT answer

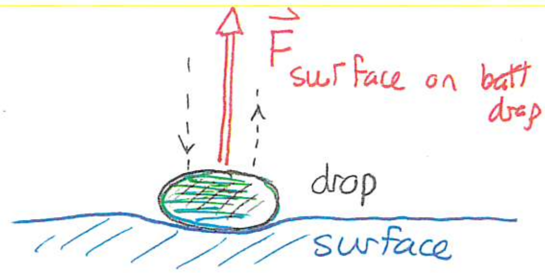
* why does an object move?
* why is the object's velocity at some instant what it is?
* why is the object at some location?

The fundamental idea will be

Interactions determine acceleration (how velocity changes)

Forces

We will need a conceptual and mathematical framework for describing interactions between objects.

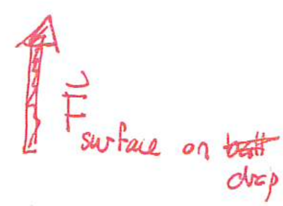


Demo: Juggling water drops video (Second video)

Consider a water drop bouncing off a surface (e.g. a water surface). During the impact the surface interacts with the drop. We use the scheme:

Drop — [Identify object of interest]   [Identify another object that interacts with the object of interest] — Surface.

[Specify a force (vector) that describes the interaction. This has:
a) magnitude = strength of push/pull in interaction
b) direction = direction of push/pull in interaction.]



This force vector will be constructed so as to capture all physical aspects of the interaction. The syntax of this is:

[Object exerts a (type of) force on object of interest]
other object — object of interest

e.g. Surface exerts a contact force on ~~a~~ drop
different!

If we can specify such force vectors then the question is

[How do the forces on an object relate to its motion?]

Effects of forces on motion

We consider idealized experiments to illustrate the effects of forces on motion

DEMO: PhET Forces in One Dimension

- Friction X
- Vectors X

Set force to constant + observe motion
use box to control.

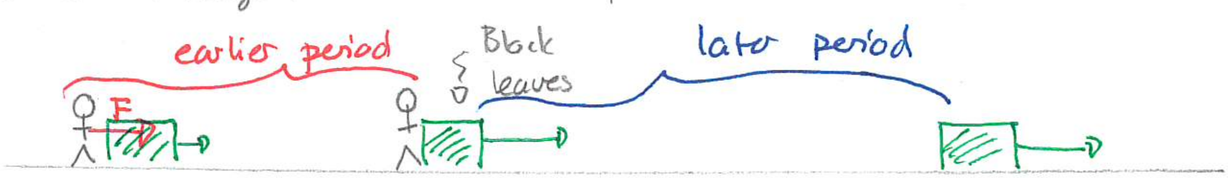
The animation suggest that

> Force is not essential for motion ⇝ An object can move even though there is no force acting on it

Separately the animation suggests

> The state of motion of an object can only change when a force acts on the object.

We can envisage this in terms of periods of motion.



- * person pushes constantly
- * person exerts a force on block
- * state of motion of block changes

include force in analysis

- * no force on block.
- * stay of motion doesn't change with time.

exclude force from analysis

Quiz 1 90%

Net force

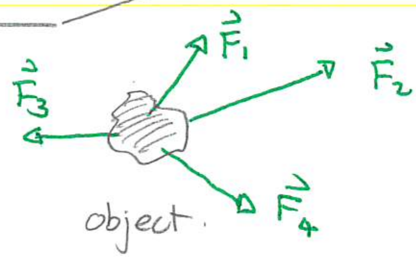
In general more than one force might act on an object in a given time. We need to combine the effects of all forces in such cases

DEMO: PhET Forces in One Dimension

- include friction + force vectors

We define the net Force

Consider an object. Suppose that forces $\vec{F}_1, \vec{F}_2, \vec{F}_3, \ldots$ act on the object. Then the net force on the object is



$$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \cdots$$

$$\vec{F}_{net} = \sum_{\text{all forces } i} \vec{F}_i$$

Quiz 2 90% // 90%

The net force must be determined at each instant during the object's motion.

Quiz 3 90% // 60% → 80%

Newton's First Law

The simplest situation to consider is that where the net force is zero. Observational evidence suggests:

> The net force on an object is zero ⟺ the velocity is constant

This is Newton's First Law. Alternatively

> The net force on an object is zero ⟺ the object's acceleration is zero.

Quiz 4

Quiz 5

DEMO: Ball / hoop