Weds: HW 5pm

Thurs: Review for Test 2

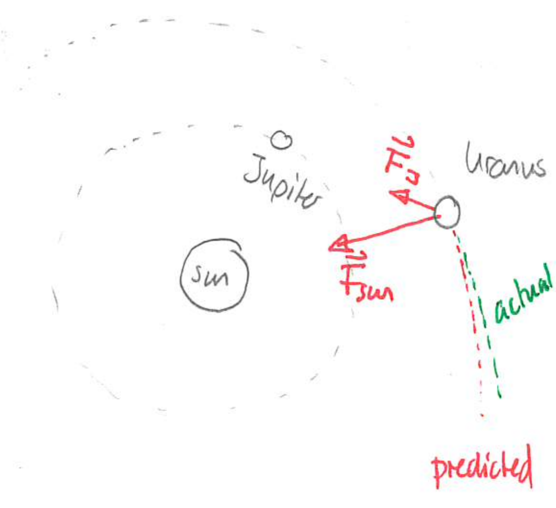
Monday, Oct 16: * ~~Test~~ Class Exam 2

* Covers all material L13 → L21
* See 2016, 2019 Exam 2 All questions

Thurs: Seminar 12:30pm WS 160

Gravitation: discovery of Neptune.

Sometimes the laws of physics can predict new phenomena or even the existence of new material objects. The discovery of Neptune was an example. By the 1780s the planets up to Uranus had been discovered. Subsequently the trajectory / orbit of Uranus could be tracked over many years. One could also use Newton's Laws and the Universal Law of Gravitation to predict the orbit. This would involve gravitational forces exerted by the Sun and each of the other planets. The best predictions provided an orbit that deviated from the true observed orbit



DEMO: PhET My Solar System - Lab

A) Single planet - preset Sun/Planet.

~~m v 3 250 2 0~~

- adjust initial v slightly.
- check follow c.o.m.

B) Add third body mass 5 - use cursor to observe deviation

The resolution to this was that a new planet, Neptune existed. Newton's mechanics could predict where this should be to create the deviation from the previously predicted orbit

New planets?

We can discover new planets by observing their gravitational effects on their host stars. Relative to observers on Earth, the host star moves slightly. This motion slightly alters the wavelengths of the emitted light and these modifications can be detected. This "radial velocity" method was the earliest to detect planets orbiting stars other than the Sun

We could also infer the existence of other planets in our solar system

DEMO: Planet 9 video

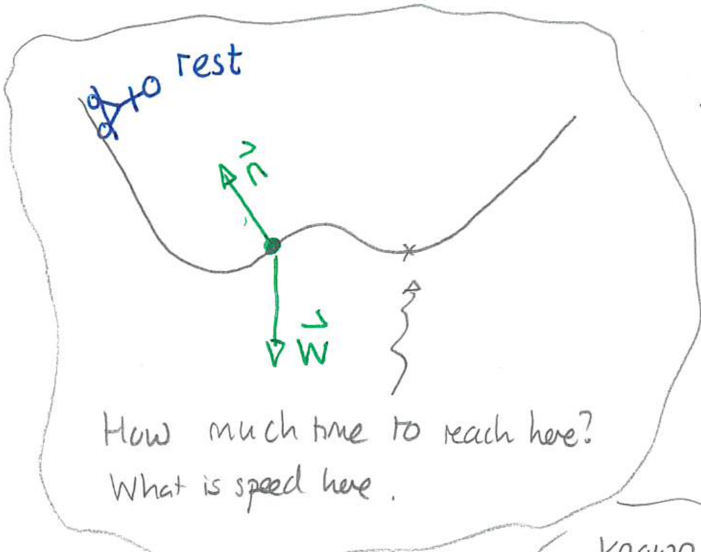
Energy in physics

Newton's system of mechanics allows one to predict the motion of any object given sufficient information about all the forces on the object. Can one always make it predict satisfactorily? Consider a skater on a track.

DEMO: PhET Energy Skate Park (Basics)

→ Intro → W shape track.

→ No friction release skater.



→ Use forces on Newton's 2nd Law

$$\sum F_{ix} = ma_x$$

$$\sum F_{iy} = ma_y$$

↓

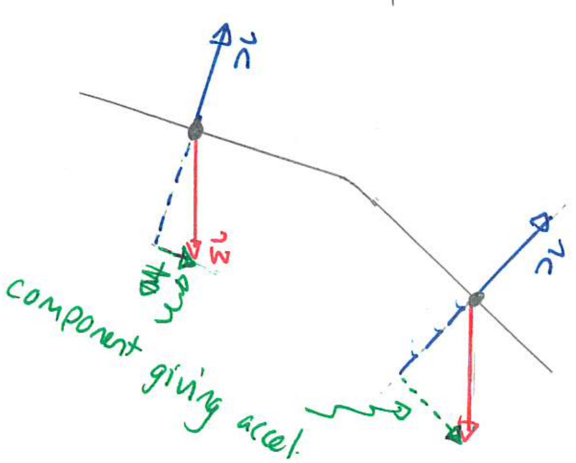
Predict acceleration

Known initial position / velocity → * Determine later positions?

* Forces vary and acceleration varies

Quiz 1 50%

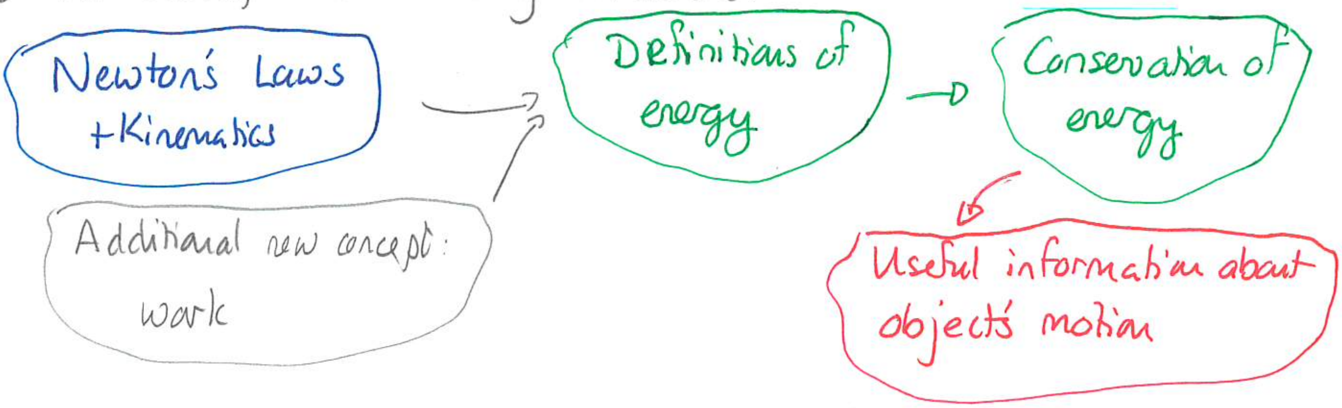
In this situation the gravitational force stays constant. The normal force varies and the component of the weight parallel to the slope varies. We will certainly not be able to use constant acceleration kinematics in such situations. The resulting mathematics will be very complicated. However, there is an alternative scheme using energy that evades these complications to help answer some questions about motion easily.



DEMO: PhET ESP

– show bar graphs

We will develop the following framework:



Energy is widespread in physics and other sciences:

* mechanics
* thermodynamics
* quantum theory
* chemistry
* biology
* climate science

DEMO: Pendulum swinging back + forth

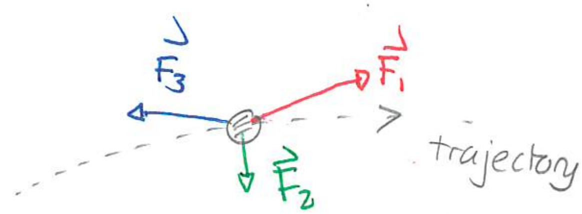
DEMO: Large pendulum (2nd video)

DEMO: ChemTube3D

Work

The crucial concept that connects forces and energy is work. Intuitively this describes the extent to which forces succeed in producing motion.

Consider an object whose trajectory is known. Then for the three illustrated forces:



1) $\vec{F}_1$ ⇝ tending to speed up object

2) $\vec{F}_2$ → " to make trajectory curve

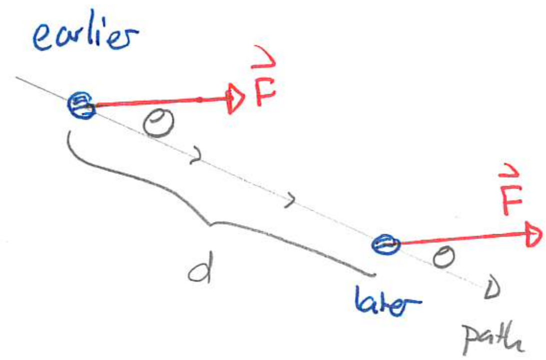
3) $\vec{F}_3$ ⇝ " " slow down object.

We want to combine forces, direction of motion and information about change in speed. We will

* First, consider a situation where forces are constant and the object moves in a straight line.
* Second, extend to more general cases.

Then:

Suppose that an object moves along a straight path. Suppose that a constant force acts on the object between an initial and final instant. Then the work done by the force is



$$W = F d \cos\theta$$

where
- F = magnitude of force (not negative)
- d = distance traveled by object (not negative)
- θ = angle from direction of motion to force

Units: Joules $J = N \cdot m$

Quiz2

The work can be positive, negative or zero.

Angle between force /motion	$\cos\theta$	work	affect of force on motion
$\theta = 0$	1	+	speeds up.
$0^\circ < \theta < 90^\circ$	+	+	" "
$\theta = 90^\circ$	0	0	no affect on speed.
$90^\circ < \theta < 180^\circ$	−	−	slows down
$\theta = 180^\circ$	−	−	slows down

Quiz3