Weds: Read 6.3 – 6.5

Fri: HW

## Energy and Conservation Laws

In general we can understand the behavior of any (classical) physical system by using Newton's Laws of Mechanics. Examples include:

1) projectiles

   DEMO: PhET Projectile Motion

2) objects sliding on tracks /skating /skiing

   DEMO: PhET Energy Skate Park (Basics)

   DEMO: Loop-the-loop

3) gases

   DEMO: PhET Gas Properties

4) electric power generation

   DEMO: energynewsnow video (about 5 min)

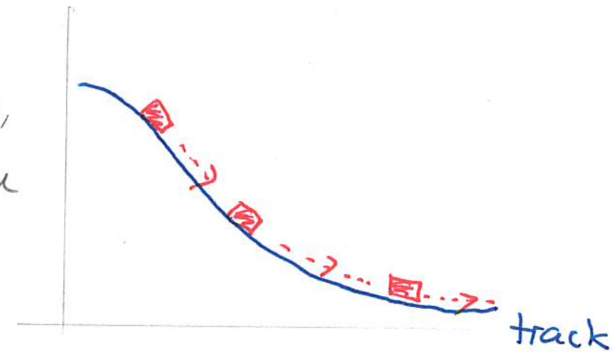
These are listed in order of increasing difficulty to explain in terms of basic mechanics (or electricity and magnetism). However, crucial aspects of all of these can be described in terms of

> Energy → a system of accounting (bookkeeping) that helps describe functioning of these systems

# Energy in Mechanics

We will begin by describing energy in relatively simple mechanical systems, which can also be analyzed in terms of forces. Consider an object sliding along a track.

When the shape of the track is more complicated that a straight line, the analysis using forces and acceleration becomes difficult. The animation shows an alternative




DEMO: PhET Energy Skate Park (Basics)

- Intro Tab →  track
- Observe motion
- Observe Bar Graph – kinetic, potential, total
  - observe constant interplay.

For simple mechanical motion, there are two types of energy that are required

## KINETIC ENERGY

* associated with motion of mass

Kinetic energy = $\frac{1}{2}$ x (mass) x (speed)$^2$

$KE = \frac{1}{2} m \times v^2$

KE in Joules (J); m in kg; v in m/s

## POTENTIAL ENERGY

* associated with vertical position of mass.

potential energy = mass x 9.8 x vertical height above ground

$PE = m \times g \times h$

PE in Joules; m in kg; g in m/s$^2$; h in m

## TOTAL (MECHANICAL) ENERGY

* add all types of energy

Total energy = kinetic energy + potential energy $E = KE + PE$

Then, one can use Newtonian mechanics to show that in situations where objects slide along tracks/slopes/ramps and there is no friction:

> At all times while the object moves, the total energy stays constant.

This is an example of the <u>Conservation of Energy</u>.

**Quiz 1** 30% - 90%

We now consider this for the skater sliding down a frictionless track.

**DEMO:** PhET ESP ~~[illegible]~~

- * Measure tab
- * Track 
- * Set to 6m

**Quiz 2** 70%

**DEMO: Actual Measurements**

| | KE | PE | Release |
|---|---|---|---|
| Release | ... | ... | |
| Midway | | | |
| Bottom | | | |

These three numbers are the same

Observe:

- * KE increases as object speeds up
- * PE decreases as object drops
- * there is a constant shifting of types of energy.

In general the actual energy in any situation depends on the particular circumstances and details:

- * mass of the object
- * objects state of motion at an initial instant

**Quiz 3**

## 1 Energy and a skating dog

A dog rides a skateboard (combined mass 20 kg) up and down a curved track. The dog starts from rest at the top of the track which is 4.0 m above the ground. The lowest point on the track is at ground level.

a) Determine the kinetic energy, the potential energy and the total energy of the dog at the top of the track.

b) Determine the kinetic energy, the potential energy and the total energy of the dog when it is halfway down the track (2.0 m above the ground).

c) Determine the kinetic energy, the potential energy and the total energy of the dog when it is at the bottom of the track.

d) Determine the kinetic energy, the potential energy and the total energy of the dog when it is a quarter way up the track (1.0 m above the ground).

| Instant | KE | PE | Total Energy |
|---|---|---|---|
| Top | 0J | 784J | 784J |
| 2.0 m above ground | 392J | 392J | 784J |
| At ground | 784J | 0J | 784J |
| 1.0 m above ground | 588J | 196 J | 784J |

This are the same

a) PE = mass × 9.8 × height

= 20 × 9.8 × 4 = 784J

KE = ½ × (mass) × (speed)²

= ½ × 20 × 0² = 0J

b) PE = mass × 9.8 × height

= 20 × 9.8 × 2 = 392J

KE = Total − PE

c) PE = mass × 9.8 × height = 0

d) PE = mass × 9.8 × height =

= 20kg × 9.8 × 1.0 =