Phys 100 2024

Lecture 18

Weds: Group Exercise

Fri: HW 5pm

Energy

Newton's system of mechanics provides the tools to understand the behavior and workings of any (classical) system. Examples include:

1) projectiles

DEMO: PhET Projectile Motion → frictionless case: Phys 111, 131

2) objects sliding on tracks

DEMO: PhET Energy Skate Park ~~(Basics)~~ → straight ramp Phys 111, 131

→ curve ramp ??

→ loop ??

3) springs/mass

DEMO: ~~PhET~~ Spring / mass → general Phys 230

4) gases

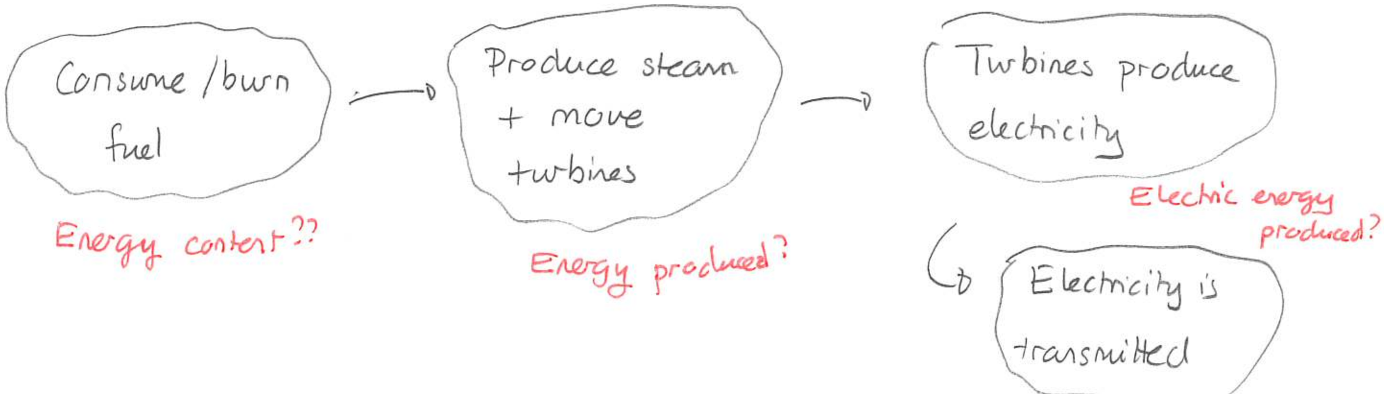
DEMO: PhET Gas Properties → few particles ??

– many particles ??

DEMO: Chain Fountain

Some of these situations are fairly easy to describe thoroughly using basic mechanics (and perhaps electricity + magnetism). Others are more difficult and some are seemingly impossible.

Certain practical situations can be extremely complex. For example our energy generation process involves



DEMO: Energy 101: Electricity Generation Video.

Despite the complication of such systems we can account for what is going on in terms of a physical quantity called energy.

Conceptually we will have:

Energy ⇝ a (bookkeeping/accounting) quantity that allows one to track / assess / predict physical situations.

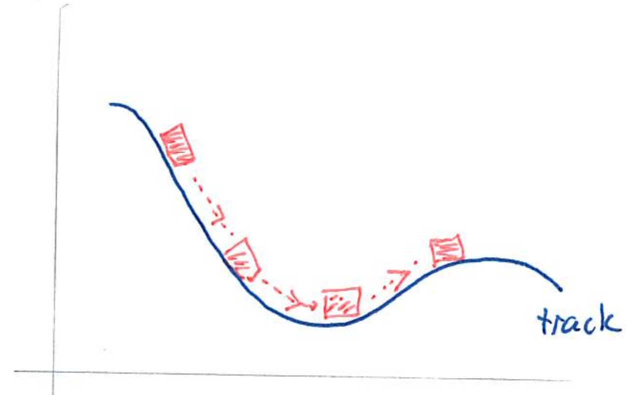
↓

Energy conservation ⇝ a rule for doing the bookkeeping

We will start by describing energy in simple physical systems.

Energy in Mechanics

Consider a situation where an object slides down a track. In principle, we could analyze this using Newton's Second Law. But the analysis is difficult when the track curves.



Fortunately one can show that there is an alternative.

DEMO: PhET Energy Skate Park (Basics)

* Intro Tab → Track ∪
  → Friction none
* Observe → Motion
* Observe → Bar Graph

The bar graph shows three types of energy: kinetic, potential and total.
KE PE

Quiz 1

Starting with Newton's Second Law one can derive (for this situation)

KINETIC ENERGY

* associated with moving mass

Kinetic Energy = $\frac{1}{2}$ × mass × speed^2

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

- KE → In Joules (J)
- m → In kg
- v → In m/s²

POTENTIAL ENERGY

* associated with vertical position of mass

Potential Energy = mass × 9.8 × vertical height above ground

$PE = m \times g \times h$

- PE → J
- m → kg
- g → m/s²
- h → m

DEMO: PhET ESP (Basics)

- Observe in relation to previous quiz

Quiz 2 30% – 70%

These combine to give

TOTAL (MECHANICAL) ENERGY

* add all types of energy

Total energy = kinetic energy + potential energy

Then, for objects that slide along tracks/slopes/ramps and where there is no friction:

At all times while the object moves, the total energy stays constant (always has the same value)

This is an example of the Law of Energy Conservation

DEMO: PhET ESP – show bar graph fluctuating

Quiz3

Note that in these situations

* KE increases as object speeds up /// decreases as object slows
* PE " as object ascends /// decreases as object descends
* energy constantly shifts from one type to another.

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	196J	784J

These are always the same

a) $KE = \frac{1}{2} \times m \times v^2 = \frac{1}{2} \times 20kg \times 0m/s^2 = 0$

$PE = m \times g \times h = 20kg \times 9.8m/s^2 \times 4.0m = 784J$

} ⇒ total = 784J

b) $PE = m \times g \times h = 20kg \times 9.8m/s^2 \times 2.0m = 392J$

$KE + PE = 784J \Rightarrow KE + 392J = 784J \Rightarrow KE = 784J - 392J = 392J$

⇒ KE = Total − PE

c) $PE = 20kg \times 9.8m/s^2 \times 0m = 0J$ ....

d) $PE = 20kg \times 9.8m/s^2 \times 1m = 196J$