PHY100S - The Magic of Physics - Class 14

A letter by Einstein in 1912 while building the General Theory of Relativity: "I am exclusively occupied with the problem of gravitation and hope with the help of a local mathematician friend to overcome all difficulties. One thing is certain, however, is that never in my life have I been quite so tormented."

§11.1 - Relativity of Speeds

Did much of this in Class 10

$$speed = \frac{distance}{time}$$

Class 11

sound wave!

1200 km/hr wrt air

pursue @ 99% of 1200 km/hr

wrt air

speed of sound wrt you 12 km/hr

actually: 12.000 000 000 015 km/hr

launcher
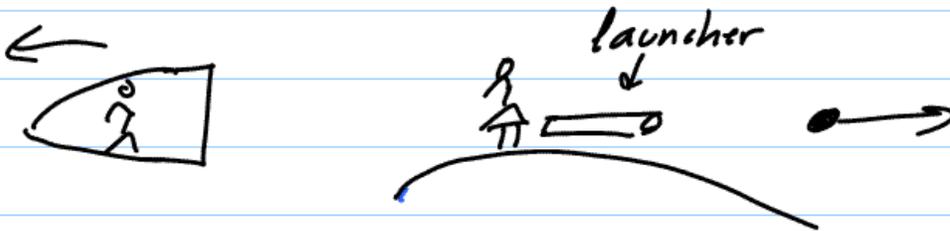


ball speed for Velma! $0.99c$ ✓
Mort's speed for Velma! $-0.99c$
Velma's speed for Mort! $+0.99c$ ✓

ball speed for Mort: $0.999949c$

Speed of ball less than c
for all observers ←

§11.3 — Inertia

$$a = \frac{F}{m}$$ ← increases with speed

object.   apply constant force $\underline{F}$

speed

c

time

mass

rest
mass

mass →
infinity
as speed → c

speed

c
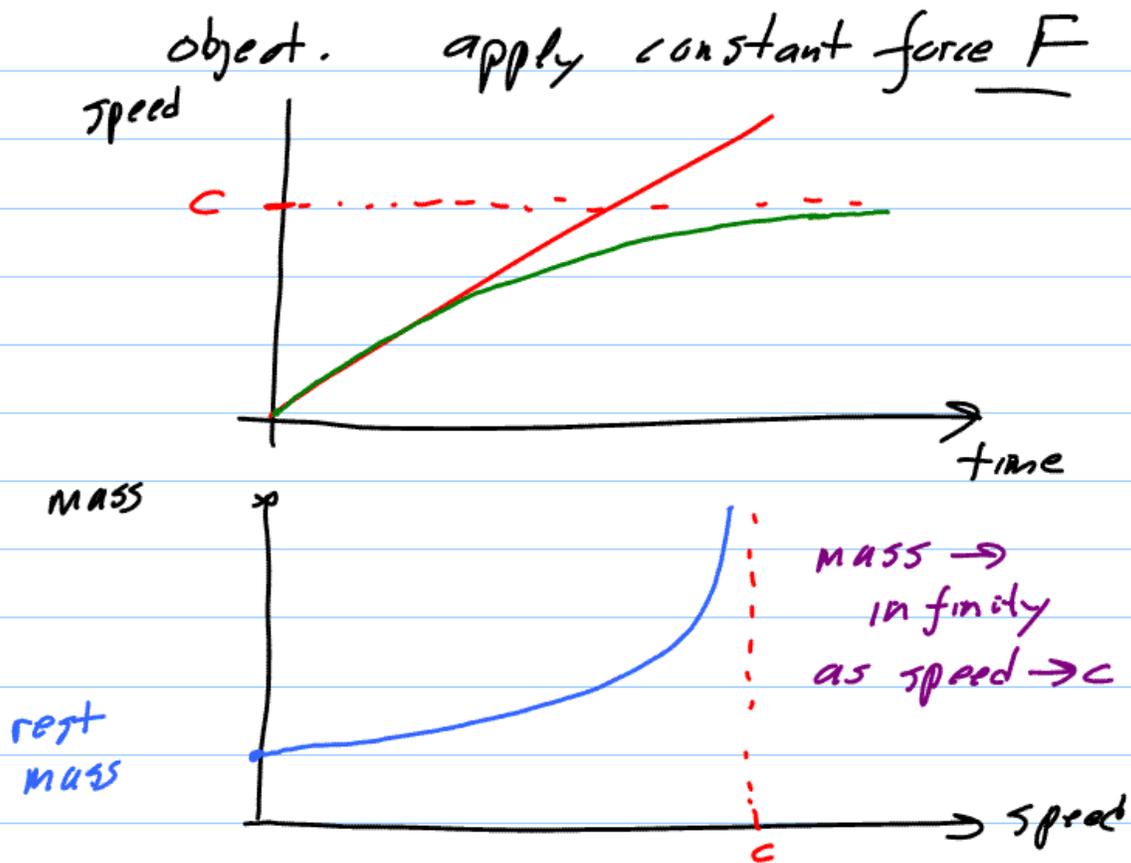
§11.4   Mass- Energy Equivalence

Kin E $\}$ increase with speed

mass $\}$

$$E = m$$

$$Kin\,E = \frac{1}{2}\,mass\,(speed)^2$$

To fix units: $\boxed{E = mc^2}$

<u>xptly tested many times</u>

at rest   rest mass M_0

$$E = M_0 c^2$$

moving! $E = Mc^2$

<u>$Kin\,E = Mc^2 - M_0 c^2$</u>

<u>Example</u>:   electron: $(-)^{ve}$ electric charge.

antimatter electron: identical but
"positron" $(+)^{ve}$ charge

PAIR PRODUCTION: intense light
energy forms electron/
positron pair

positron collides with some
other electron — both annihilate

§11.5 – NTA

§11.6   General Theory

"Special"   observers in uniform
(1905)   relative motion

"General"   observers in any
(1917)   relative motion

↳ also a theory of
   gravity

EARTH

distant   light
star

SUN
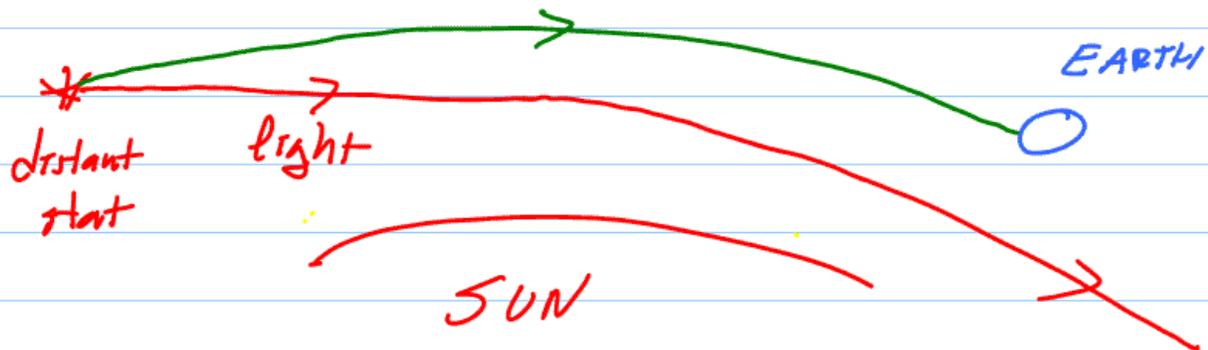
"Gravity" distortion in geometry
of spacetime around
masses

No Forces due to gravity

§ 11.7 - 11.8   Cosmology

Gen. Rel. predicts
Universe is expanding
Evptly confirmed

Matter attracts all other
matter: decreasing rate
of expansion

15 billion years ago "Big Bang"

By 1990! cosmology understood
STANDARD HOT BIG BANG
model

Is there mass in universe to reverse expansion?

YES!   universe ends in a
            BIG CRUNCH
            "closed"

NO!   uniform universe
        const temp

Big Problems!

  ① Dark matter: 40 times
           mass of all the suns
  ② Perlmutter (1998)
          rate of expansion of
          universe increasing.