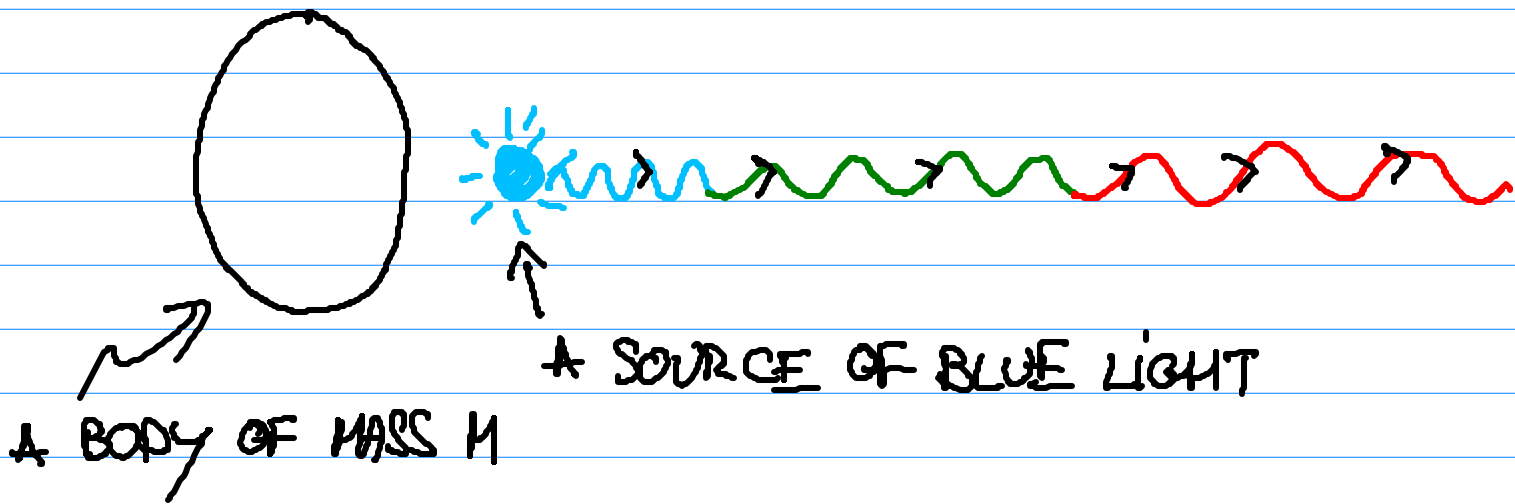


# IMPORTANT RESULTS OF THE GENERAL THEORY OF RELATIVITY:

## GRAVITATIONAL REDSHIFT:

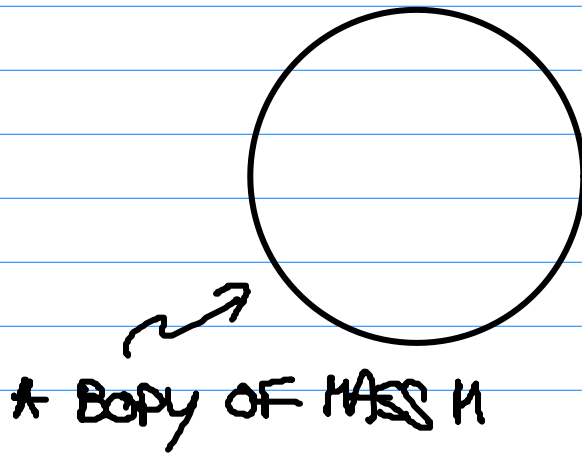
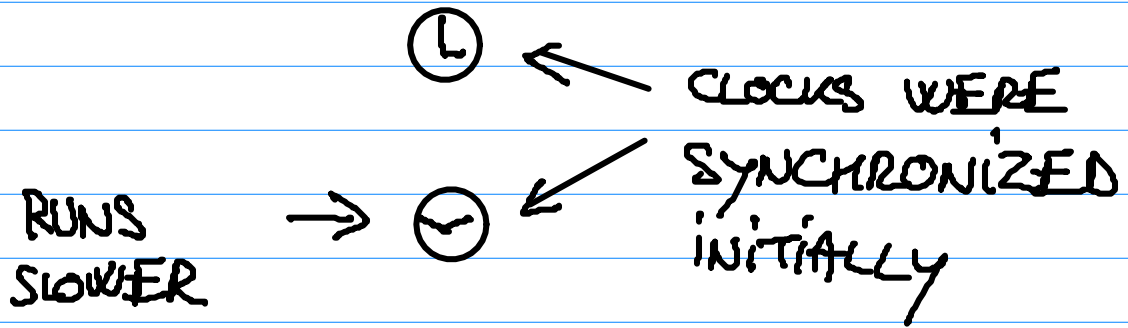


AS THE PHOTON ESCAPES THE GRAVITATIONAL WELL BY MASS M IT LOSES ENERGY AND THE WAVELENGTH OF LIGHT INCREASES:

$$\text{PHOTON ENERGY} = \frac{\text{CONSTANT}}{\lambda} \leftarrow \text{WAVELENGTH}$$

THE GRAVITATIONAL REDSHIFT IS DIFFERENT FROM THE ONE CAUSED BY THE DOPPLER EFFECT WHEN THE SOURCE IS MOVING AWAY FROM THE OBSERVER.

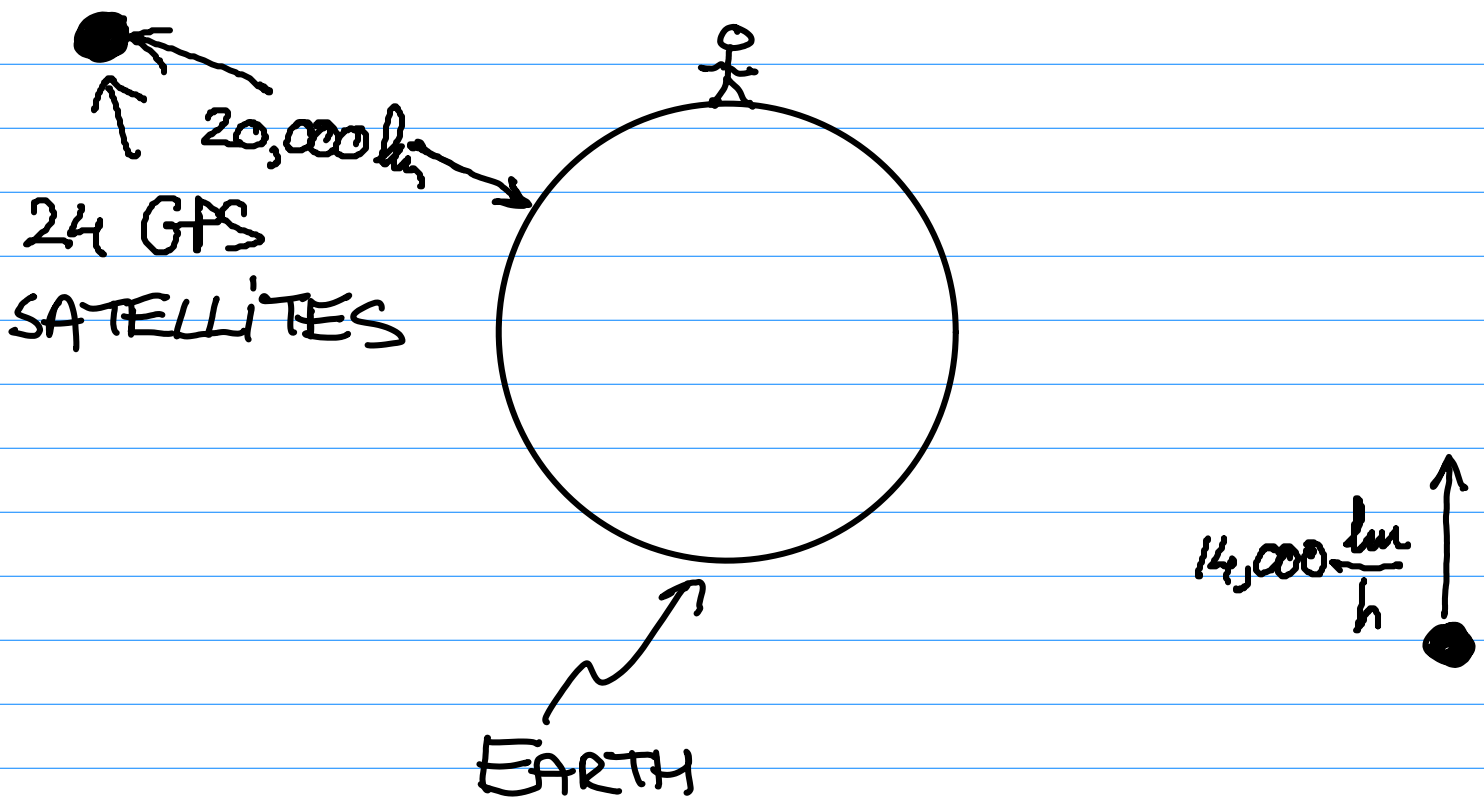
THE STRONGER THE FORCE OF GRAVITY,  
THE SLOWER THE CLOCKS RUN :



THE RELATIVISTIC EFFECTS (BOTH SPECIAL AND GENERAL THEORY OF RELATIVITY) MUST BE TAKEN INTO ACCOUNT WHEN DESIGNING THE

GPS ← SYSTEM

GLOBAL POSITIONING



CLOCKS ON THE SATELLITES RUN  $45 \mu\text{s} =$   
 $= 45 \times 10^{-6}$  S FASTER PER DAY THAN THE  
 GROUND CLOCKS (GENERAL RELATIVITY)

BECAUSE THE SATELLITES ARE MOVING THEIR  
 CLOCKS ARE RUNNING  $7 \mu\text{s}$  SLOWER PER DAY  
 (SPECIAL RELATIVITY)

THE NET EFFECT IS  $45 \mu\text{s} - 7 \mu\text{s} = 38 \mu\text{s}$   
 TOO FAST PER DAY.

THE SPEED OF LIGHT  $\approx 1 \frac{\text{foot}}{\text{ns}}$  ( $1 \text{ ns} = 10^{-9} \text{ s}$ )

THE DISTANCE THE LIGHT TRAVELS IN  $38 \mu\text{s}$  IS

$$\frac{38000 \text{ ns}}{38 \mu\text{s}} \cdot 1 \frac{\text{foot}}{\text{ns}} / \text{PER DAY} = 38,000 \text{ foot} / \text{PER DAY} \approx \\ \approx 11 \text{ km} / \text{DAY}$$

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## THE MILKY WAY GALAXY (Ch. 16)



A DIFFUSE BAND OF LIGHT ACROSS THE SKY.

IN 1609 GALILEO OBSERVED THAT IT CONSISTS OF VERY MANY FAINT STARS - FAINT BECAUSE THEY ARE AT A GREAT DISTANCE.

IN THE 18TH CENTURY IT WAS PROPOSED BY THOMAS WRIGHT AND BY IMMANUEL KANT THAT WE OBSERVE IT BECAUSE WE LIVE IN A DISK OF STARS

