

Wireless download
home work ...
Quick! ...
... Cut and paste ...
... HOMEWORK
DONE!!!



Hello...??
No problem Saar!
Your scooter is
running fine!

Renewable Energy Technologies

Learning Objectives:

- 1) The scale of commonly encountered quantities
- 2) The scale of some quantities not so commonly encountered
- 3) The scale of energy usage of the world

Scales of quantities:



Femto	10^{-15}
Pico	10^{-12}
Nano	10^{-9}
Micro	10^{-6}
Milli	10^{-3}
Kilo	10^3
Mega	10^6
Giga	10^9
Tera	10^{12}
Peta	10^{15}
Exa	10^{18}
Zetta	10^{21}
Yotta	10^{24}

10^{-15}

Femtosecond lasers

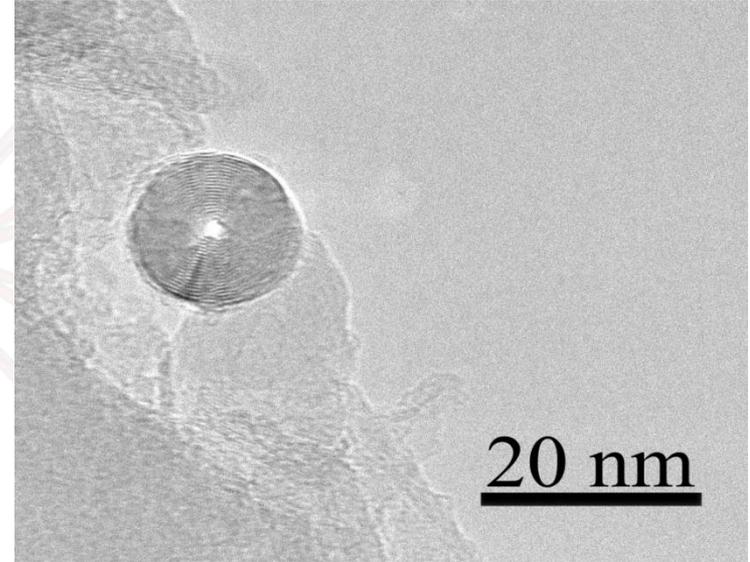
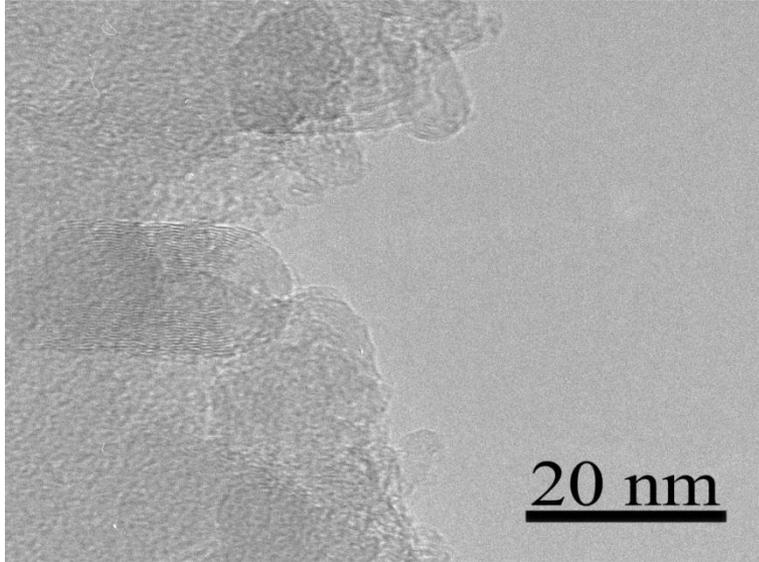


10^{-12}

**Pico ampere current sources are
used to measure resistances**

Carbon nanotubes

10^{-9}



10^{-6}

Optical microscopes show us
images that have detail or
resolution in the scale of microns

Artificial Pacemaker

10^{-6}

Uses a Lithium Iodine Battery

Power usage: $60 \mu\text{W}$

Battery Life: 5-10 years

Dr. Clarence Walton Lillehei

Earl E. Bakken:

10^{-3}

A typical scientific calculator uses
0.1 mW power

Uses 1 AA battery

Approximate

Capacity: 3 Wh

10⁰

Cameras

Power usage 3 W

Uses batteries: 14Wh

10^2

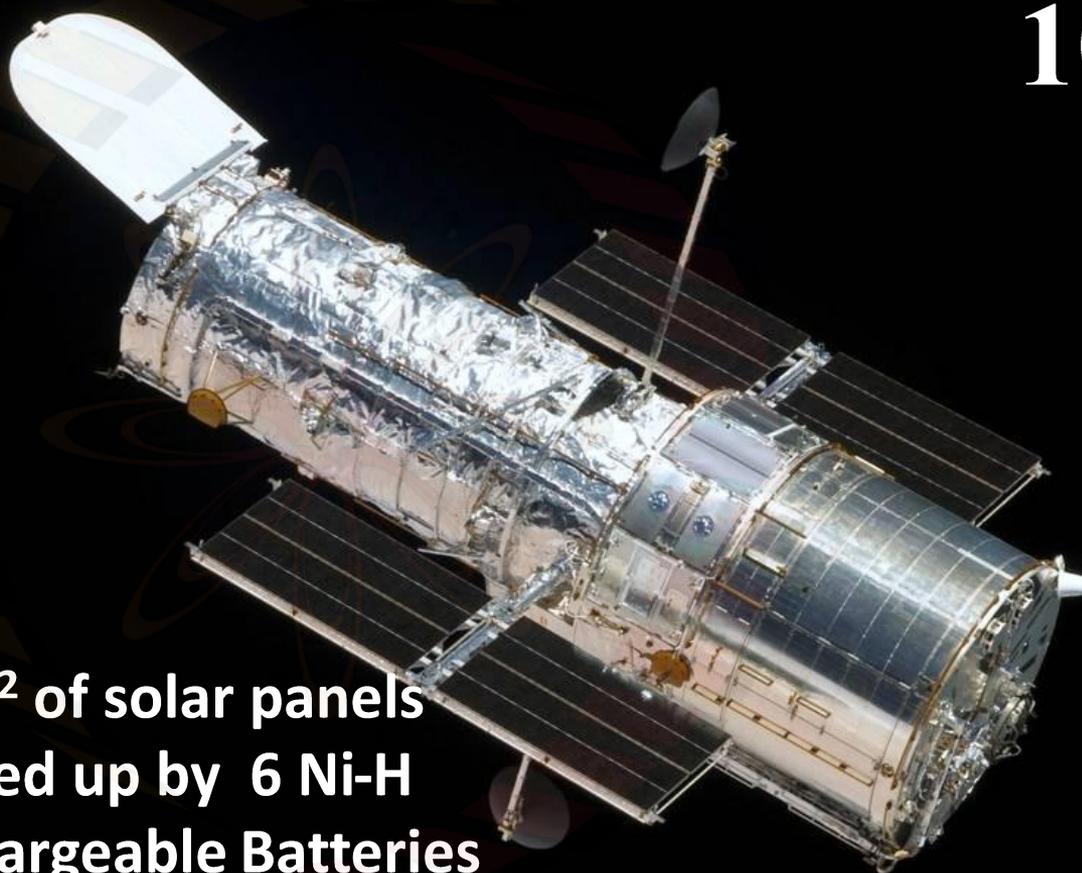
Household bulbs : 5W – 200W

**Hubble
Space
Telescope
Power
usage:
2400 W**

*Image Credit:
NASA*

**36 m² of solar panels
Backed up by 6 Ni-H
Rechargeable Batteries
Life: 5 orbits (95 minutes per orbit)**

10³

A detailed view of the Hubble Space Telescope in space. The telescope is cylindrical with a large white mirror at the front. It has several solar panels extended from its sides and a large antenna at the back. The background is black with some faint circular patterns.

10³

Batteries in cars

Power usage 5000 W

Pb-Acid Batteries

Approximate

Capacity: 600 Wh

10^4



Power usage: 20 KW

Battery capacity: 30 KWh



Petrol/Electric Hybrid Propulsion 10^4

Uses Ni-MH Batteries

Fuel Efficiency: Approximately 28
Km/l

Power Usage: 60 KW

Battery capacity: 1 KWh

10^6

Submarines

Power usage: 500 KW – 3 MW

10^6

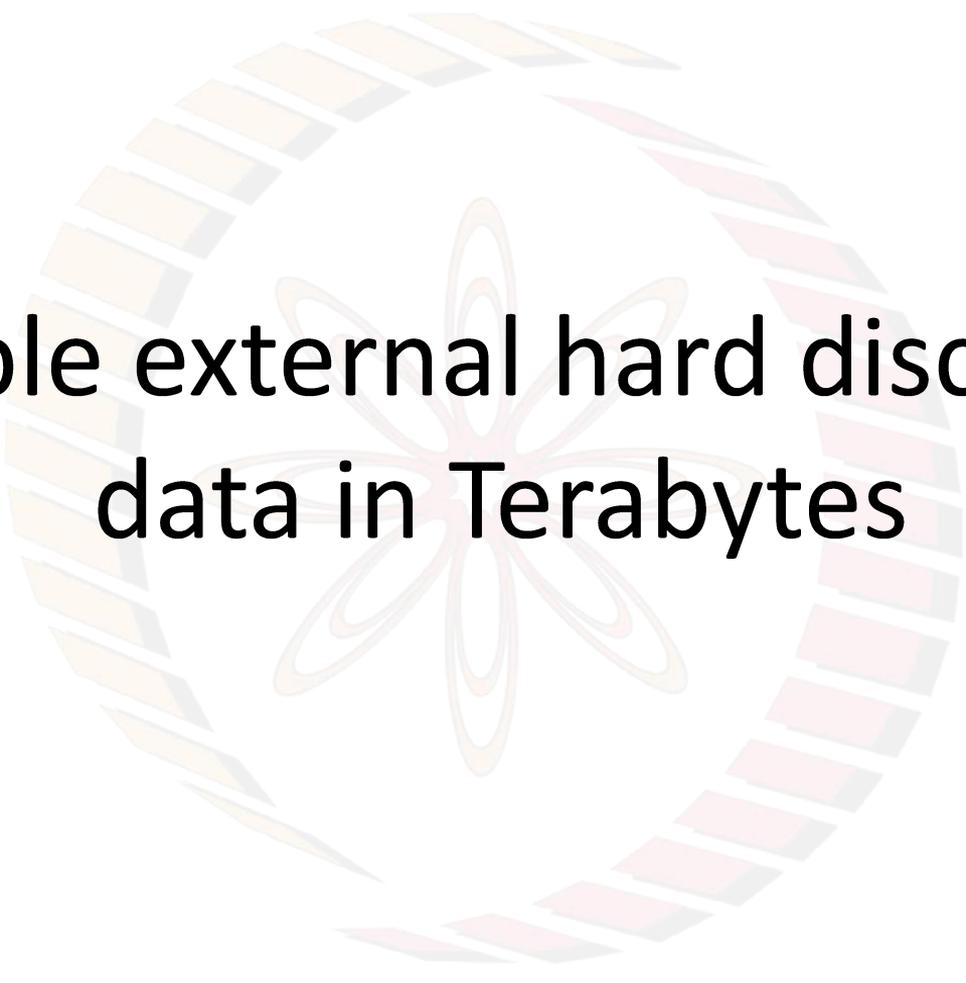
**Cameras store images in
Megapixels**

10⁹

Mobile phones store data in
several Gigabytes

10^{12}

Portable external hard discs store
data in Terabytes



10^{15}

Supercomputers operate with speeds of 10s to 100s of Petaflops.

A Petaflop is 10^{15} floating point operations per second

10^{18}



World energy usage per year : 500 exa joules

Image Credit NASA

10²¹

In 2010, Humanity is
said to have crossed 1
Zettabyte Mark in terms
of data created and
stored overall

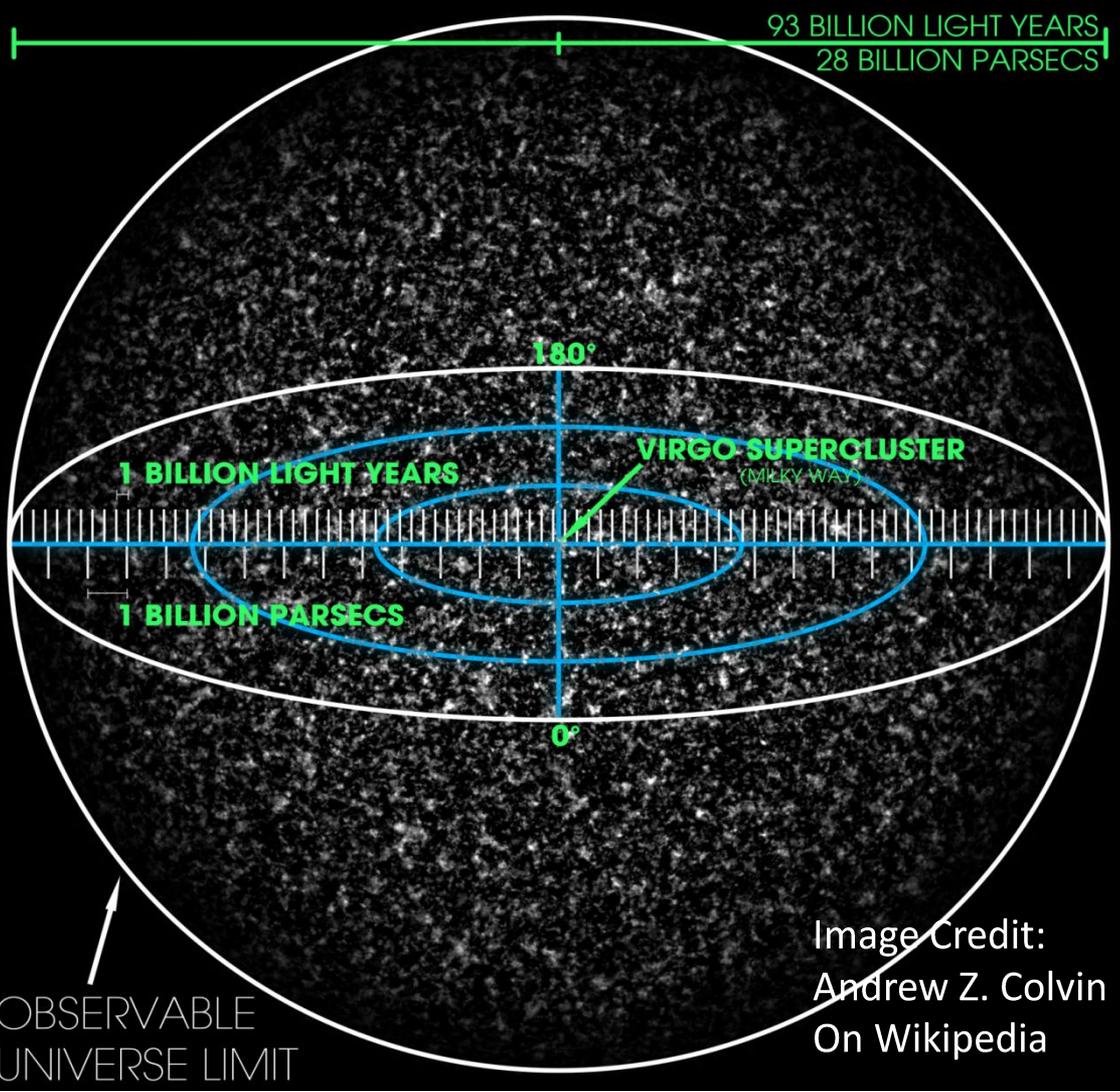
10^{24}

Massive spiral galaxy NGC 5746

Chandra observatory

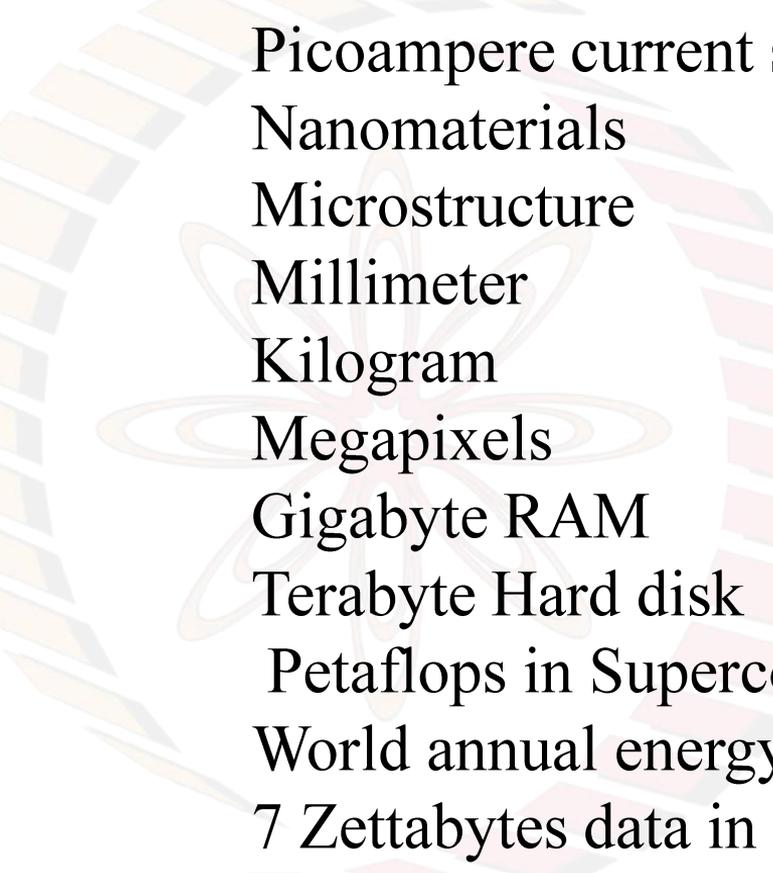
Distance Estimate About 100 million light
years (1 Ym)

Image Credit NASA



OBSERVABLE
UNIVERSE LIMIT

Image Credit:
Andrew Z. Colvin
On Wikipedia



Femto	10^{-15}	Femtosecond laser
Pico	10^{-12}	Picoampere current source
Nano	10^{-9}	Nanomaterials
Micro	10^{-6}	Microstructure
Milli	10^{-3}	Millimeter
Kilo	10^3	Kilogram
Mega	10^6	Megapixels
Giga	10^9	Gigabyte RAM
Tera	10^{12}	Terabyte Hard disk
Peta	10^{15}	Petaflops in Supercomputers
Exa	10^{18}	World annual energy usage
Zetta	10^{21}	7 Zettabytes data in 2020
Yotta	10^{24}	1 Ym ~ 100 million light years

Summary of power usage and energy storage

Device	Power usage (W)	Energy stored (Wh)
Pacemaker	6×10^{-5}	2.5
Casio fx 100 W	1×10^{-4}	3
Digital camera	3	6
Household bulb	10^2	
Hubble:	2.4×10^3	
Household	3×10^3	
Car ignition	5×10^3	6×10^2
BHEL Bus	2×10^4	3×10^4
Honda Insight	6×10^4	1×10^3
Submarines	1×10^6	
Load Leveling		5×10^7