$$A = X_s \cdot \frac{1}{1 - \frac{\omega^2}{\omega_0^2} + i\frac{\omega}{\omega_0}\frac{\gamma}{\omega_0}}$$

"scaled" frequency $r = \frac{\omega}{\omega_0}$ (=1, resonance)

Q - factor $Q = \frac{\omega_0}{\gamma}$ (bigger better) less friction

$$A = X_s \cdot \frac{1}{1 - r^2 + \frac{ir}{Q}}$$

$$\boxed{A(\text{resonance}) = \frac{X_s \cdot Q}{i}}$$

Q ... also the "amplification factor" at resonance.

i: $x(t) = \mathrm{Re}(Ae^{i\omega t})$ (steady state)

resonance

$$x(t) = \mathrm{Re}\left(\frac{X_s \cdot Q}{i}(\cos\omega t + i\sin\omega t)\right)$$

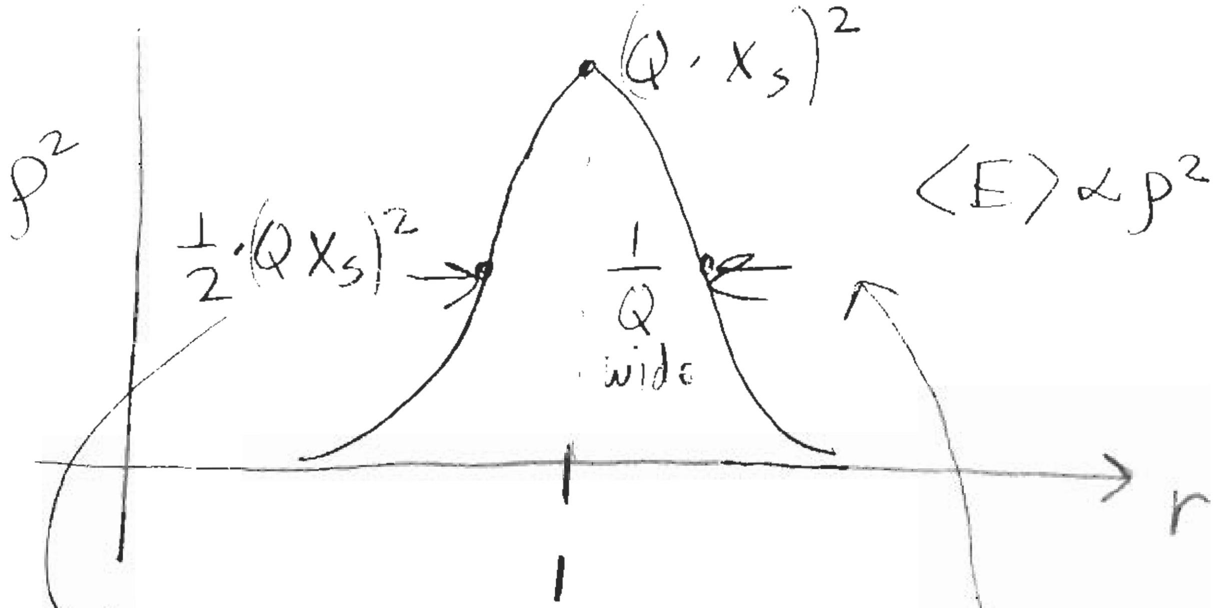
$$x(t) = X_s \cdot Q \cdot \sin\omega t$$

driving force $F(t) = F_0 \cos\omega t$

90° out of

$$\rho^2 \simeq \frac{X_s^2}{4\delta^2 + \frac{1}{Q^2}}$$

near resonance $Q \gg 1$



$\langle E \rangle \propto \rho^2$

what δ?

$$\frac{1}{2} Q^2 \cancel{X_s^2} = \frac{\cancel{X_s^2}}{4\delta^2 + \frac{1}{Q^2}}$$

$$4\delta^2 + \frac{1}{Q^2} = \frac{2}{Q^2}$$

$$\delta^2 \simeq \frac{1}{4} \frac{1}{Q^2}$$

$$\boxed{\delta = \pm \frac{1}{2} \frac{1}{Q}}$$

Special Relativity

$c = \frac{1\ \text{ft}}{\text{nanos}} = \frac{30\ \text{cm}}{\text{nanosecond}}$

(1) Speed of light (c) is finite

(a) First measured in 1676 by Ole Rømer, a Dane living in Paris. He used the orbits of the moons of Jupiter as a clock.

Large Moons of Jupiter

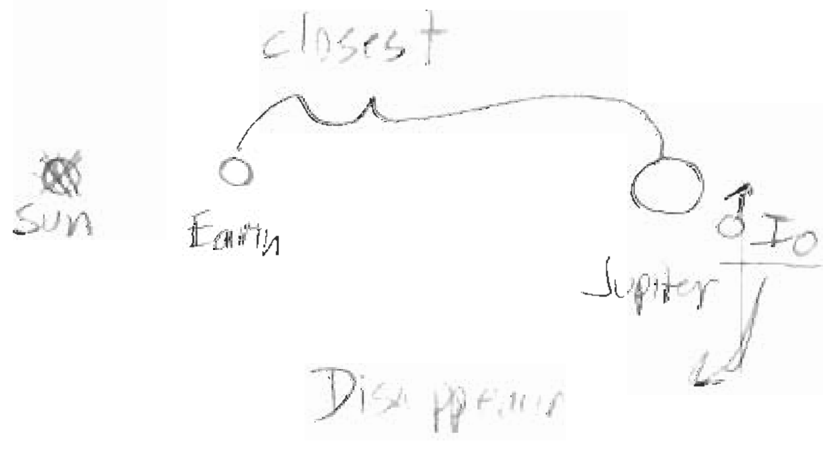
Name	Period	Diameter
Io	1.769 days	3630
Europa	3.551	3138
Ganymede	7.155	5262 ←
Callisto	16.689	4800

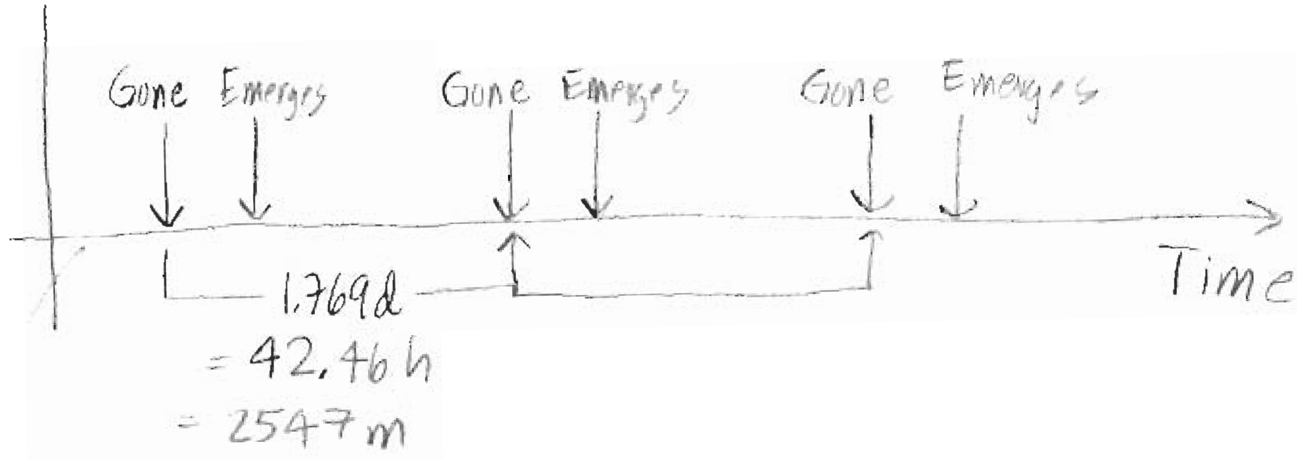
Earth (12,756 km)

(Our Moon 3476 km)

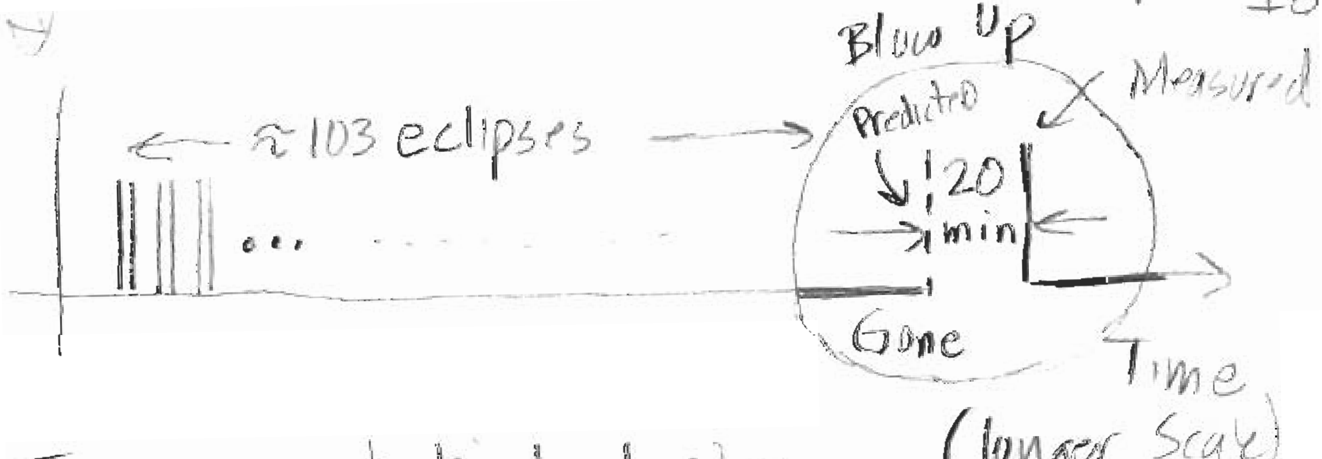
Largest Moon in Solar System, Larger than Pluto & Mercury

Imagine measuring when Io goes behind Jupiter and then when Io emerges. Start when Earth + Jupiter are closest





Jupiter takes 11.9y to orbit sun. Earth 1 year, so Jupiter almost "stands still". So, 1/2 year later, situation is:



Io passes behind Jupiter (when earth far from Jupiter) about 17 minutes later than expected (Roemer got 22 minutes)

Diameter Earth's orbit = 2 A.U.

$2AU = 2 \times 1.5 \cdot 10^8 \text{ km} = 3 \cdot 10^8 \text{ km}$

17 minutes $\simeq 10^3$ seconds

$$c \simeq \frac{3 \cdot 10^8 \text{ km}}{10^3 \text{ s}} \simeq 3 \cdot 10^5 \text{ km/s}$$

(Rømer got $2 \cdot 10^5$ km/s)

(b) Running into the rain of light