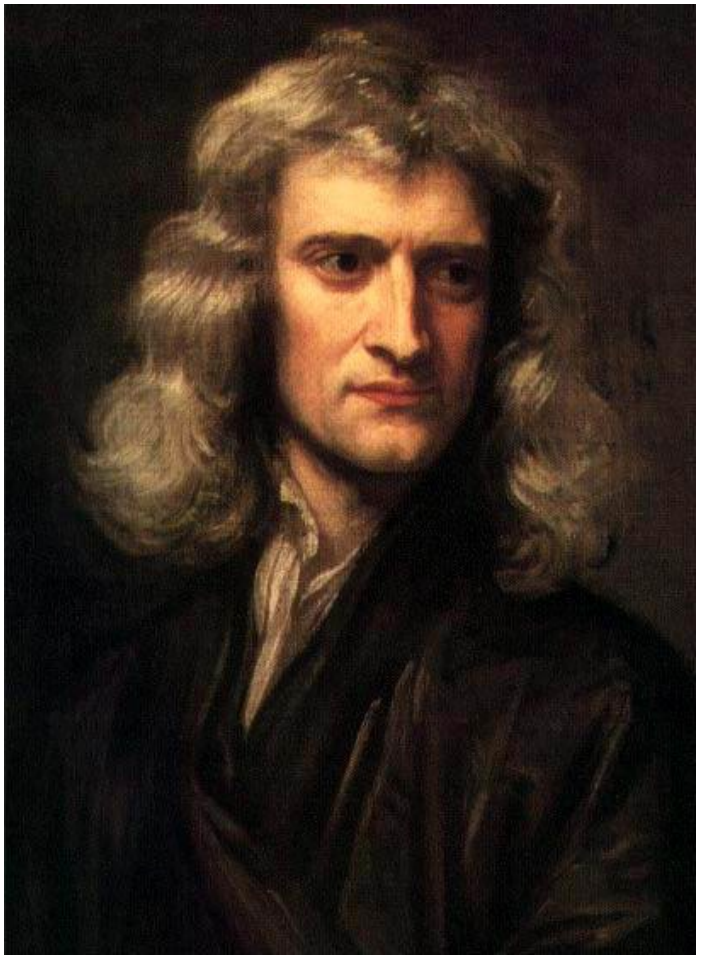
SIR ISAAC NEWTON
1643-1727

- BORN THREE MONTHS AFTER HIS FATHER DIED IN A SMALL ENGLISH TOWN THE YEAR GALILEO DIED
- HIS MOTHER REMARRIED BUT HE WAS RAISED BY HIS MATERNAL GRANDMOTHER
- HIS MOTHER WANTED TO MAKE A FARMER OUT OF HIM WHEN HIS STEPFATHER DIED BUT HENRY STOKES, MASTER AT THE KING'S SCHOOL GRANTHAM, PERSUADED HER TO SEND HIM BACK TO SCHOOL.



ISAAC NEWTON

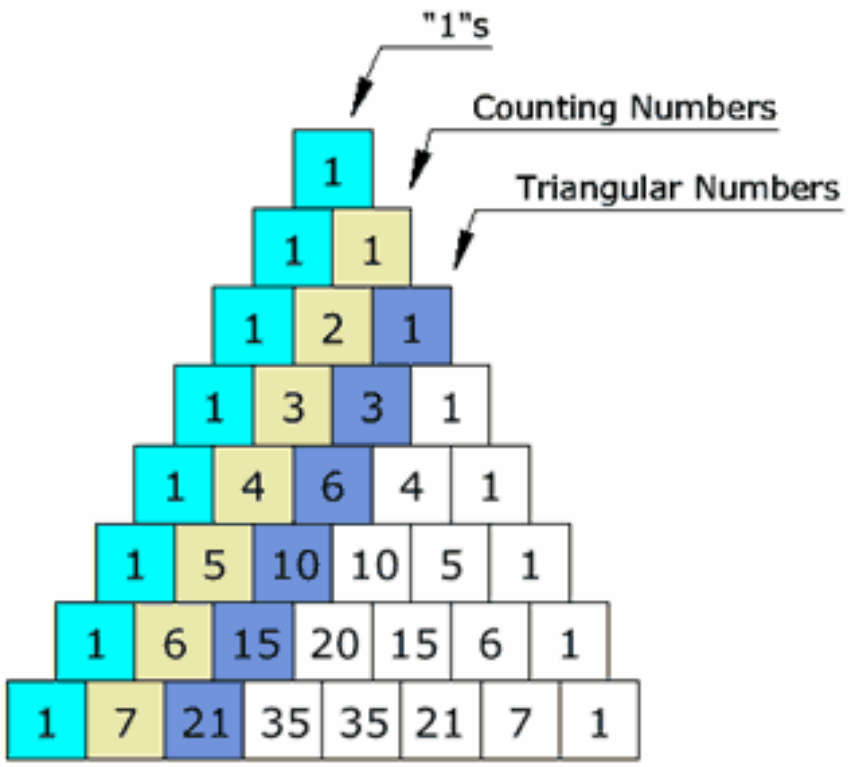
- AT AGE 18 HE ENTERED TRINITY COLLEGE, CAMBRIDGE AS A SIZAR.
- A SIZAR WAS KIND OF A “WORK-STUDY” ASSISTANTSHIP FOR TALENTED STUDENTS FROM POOR FAMILIES. THEY PAID NO TUITION BUT HAD TO PERFORM MENIAL, SOMETIMES DEMEANING TASKS AND WERE CONSIDERED SUBORDINATE TO TUITION PAYING STUDENTS.
- WHILE ARISTOTILEAN PHILOSOPY WAS EMPHASIZED THERE HE PREFERRED TO STUDY DESCARTE.
- HE ALSO IMMERSED HIMSELF IN THE STUDY OF COPERNICUS, GALILEO AND KEPLER

ISAAC NEWTON

- WHEN HE WAS 22 HE DISCOVERED THE GENERALIZED BINOMIAL THEOREM, AN EXPRESSION DESCRIBING THE EXPANSION OF A BINOMIAL RAISED TO A GIVEN POWER
- FOR EXAMPLE THE COEFFICIENTS IN THE EXPRESSION:

$(x+y)^4=x^4+4x^3y+6x^2y^2+4xy^3+y^4$

CAN BE EASILY SEEN USING THE TRANGLE AT THE RIGHT CALLED PASCAL'S TRIANGLE



ISAAC NEWTON

- HE GRADUATED AT AGE 22 AND, BEFORE HE COULD EMBARK ON HIS GRADUATE STUDIES THE GREAT PLAGUE (THE BUBONIC PLAGUE) HIT IN 1665. IT KILLED OVER 100,000 PEOPLE, OVER 20% OF LONDON'S POPULATION.
- HE SPENT THE NEXT TWO YEARS AT HOME WHERE HE DEVELOPED HIS BASIC THEORIES ON CALCULUS, OPTICS, HIS LAWS OF PHYSICS AND HIS LAW OF UNIVERSAL GRAVITATION.
- HE DEVELOPED CALCULUS (FLUXIONS AND INVERSE FLUXIONS) TO SOLVE ONE OF THE PROBLEMS HE FACED IN DEVELOPING HIS LAW OF UNIVERSAL GRAVITATION.
- HE CALLED THIS PERIOD, "the prime of my age for invention"
- DURING THAT TIME HE WROTE A LARGE PART OF WHAT BECAME *Philosophiae Naturalis Principia Mathematica* OR WHAT WE NOW SIMPLY CALL "THE PRINCIPIA"
- HOWEVER IT WASN'T PUBLISHED UNTIL TWENTY YEARS LATER IN 1687 AT THE INSISTANCE AND GENEROUS SUPPORT OF EDMOND HALLEY.
- ALSO, BY THE MID-60'S HE HAD ALSO INDEPENDENTLY DERIVED THE EXPRESSION: $F=mv^2/r$ FOR THE CENTRIPITAL FORCE THAT HUYGENS HAD DERIVED.

ISAAC NEWTON

- DURING THE INTERVENING TIME HE AND HOOKE HAD SEVERAL DISCUSSIONS ON THE NATURE OF THE CARTESIAN FORCES DESCRIBED BY DESCARTE.
- THEY ALSO ARGUED ABOUT WHETHER ONE SHOULD EXPECT AN OBJECT DROPPED FROM THE TOP OF A TOWER WOULD BE EXPECTED TO FALL STRAIGHT DOWN TO THE FOOT OF THE TOWER OR WHETHER THE EARTH'S MOTION SHOULD MAKE IT ALIGHT BEHIND THE OBSERVER.
- NEWTON ARGUED THAT, SINCE THE TOP OF THE TOWER IS FARTHER FROM THE CENTER OF THE EARTH IT WOULD BE MOVING FASTER THAN THE BASE AND, IN FACT, SHOULD FALL IN FRONT OF THE TOWER. IN FACT HE ARGUED, CORRECTLY, THAT, IF THE EARTH WERE NOT IN THE WAY THE OBJECT WOULD GO INTO ORBIT AROUNG THE CENTER OF THE EARTH.
- IN FACT, IF THE SURFACE OF THE EARTH DIDN'T INTERVENE WE WOULD FALL INTO ORBIT AROUND ITS CENTER

NEWTON'S LAWS OF MOTION

1. AN OBJECT WILL REMAIN IN UNIFORM MOTION UNLESS ACTED ON BY AN OUTSIDE UNBALANCED FORCE. (dp/dt=0)
2. IF AN OUTSIDE UNBALANCED FORCE, F, IS APPLIED TO A MASS , m, IT WILL PRODUCE AN ACCELERATION , a, GIVEN BY THE EXPRESSION, F = dp/dt=d(mv)/dt=ma WHERE p IS THE MOMENTUM. THIS EXPRESSION DEFINES "INTERTIAL MASS".
3. FOR EVERY FORCE OF ACTION THERE IS AN EQUAL AND OPPOSITE FORCE OF REACTION.

NEWTON'S LAW OF UNIVERSAL GRAVITATION

- THERE WILL BE AN ATTRACTIVE FORCE , F, BETWEEN ANY TWO MASSES, m_1 AND m_2, SEPARATED BY A DISTANCE r GIVEN BY THE EXPRESSION: $F = Gm_1m_2/r^2$ WHERE G IS THE UNIVERSAL GRAVITATIONAL CONSTANT. THIS EXPRESSION DEFINES "GRAVITATIONAL MASS". NEWTON DEVOTED A GOOD DEAL OF TIME TO PROVING THAT INERTIAL AND GRAVITATIONAL MASS ARE THE SAME.

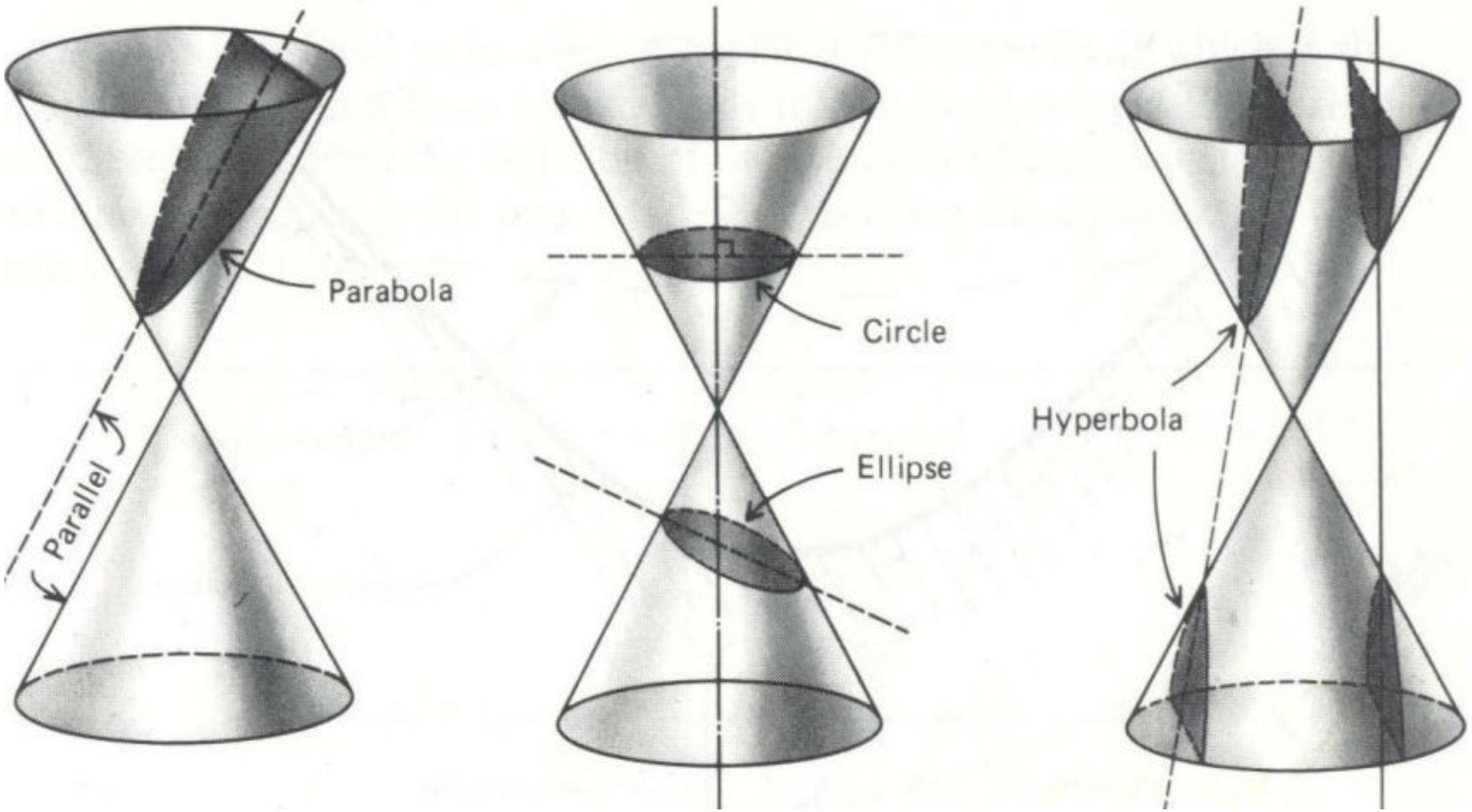
ISAAC NEWTON

- ONE PROBLEM HE HAD TO OVERCOME: HE COULDN'T SEE HOW THE GRAVITATIONAL FORCE WOULD NOT BE SHIELDED BY INTERVENING MATTER.
- WHEN HE DID REALIZE THAT THE INTERVENING MATTER DID NOT SHIELD THE GRAVITATIONAL FORCE HE STATED "THE ATTRACTION LAW MUST BE IMPOSED BY GOD".
- ANOTHER PROBLEM: HOW DO YOU CALCULATE THE GRAVITATIONAL FORCE BETWEEN THE MILLIONS AND MILLIONS OF MASSES THAT MAKE UP THE MOON AND THE EARTH?
- FOR THIS HE INVENTED CALCULUS AND PROVED THAT, IF THE MASSES WERE UNIFORM AND SPHERICAL THAT ONE COULD ASSUME THAT ALL OF THEIR MASS WAS AT THEIR CENTERS AND TREAT THEM AS POINTS.

ISAAC NEWTON

- HALLEY HAD DISCUSSED THE DYNAMICS OF PLANETARY ORBITS WITH HOOKE.
- HALLEY WAS FLABBERGASTED WHEN HE ASKED NEWTON ABOUT THE SHAPE OF A PLANET'S ORBIT AND NEWTON REPLIED IMMEDIATELY THAT IT WAS AN ELLIPSE.
- IN FACT HE WOULD LATER SHOW THAT, MORE GENERALLY, IF ONE SOLVED THE SIMULTANEOUS EQUATIONS OF NEWTON'S 2^{ND} LAW AND HIS LAW OF UNIVERSAL GRAVITATION THAT THE ORBITS WOULD BE CONIC SECTIONS.

CONIC SECTIONS



ECCENTRICITIES OF CONIC SECTIONS

- FOR BOUND ORBITS
  - FOR A CIRCLE: e = 0
  - FOR A NONCIRCULAR ELLIPSE: 0<e<1
- FOR UNBOUND ORBITS
  - FOR A PARABOLA: e=1 (v = ESCAPE VELOCITY)
  - FOR A HYPERBOLA: e>1 (v > ESCAPE VELOCITY)

THE SUCCESSES OF NEWTON'S LAWS

- THE MOON'S ORBIT WAS CORRECTLY DESCRIBED
- THE TIDES WERE EXPLAINED
- THE EARTH'S BULGE WAS CORRECTLY PREDICTED
- PRECESSION OF THE EQUINOXES (CAUSED BY THE MOON'S ATTRACTION ON THE EARTH'S EQUATORIAL BULGE)

KEPLER'S LAWS RESTATED

1. PLANETS MOVE IN ELLIPTICAL ORBITS, THE CENTER OF MASS AT THE FOCUS.
2. THE RADIUS VECTOR SWEEPS OUT EQUAL AREAS IN EQUAL TIMES (UNCHANGED EXCEPT THE RADIUS VECTOR HAS TWO SECTORS, NOT ONE)
3. $P^2(M_S+M_P) = ka^3$ WHERE THE MASSES ARE GIVEN IN SOLAR MASSES , P IN EARTH YEARS AND a IN ASTRONOMICAL UNITS.

ISAAC NEWTON

- CENTER OF MASS (BARYCENTER)
- MR = mr WHERE M AND m ARE THE MASSES AND R AND r ARE THEIR RESPECTIVE DISTANCES FROM THE CENTER OF MASS
- GO TO http://www.youtube.com/watch?v=_IHXj8k2jqc

  TO SEE HOW THE SUN MOVES DUE TO ALL OF THE OBJECTS IN THE SOLAR SYSTEM REVOLVING AROUND IT AND HOW THE PLANETS' ORBITS WOBBLE.

THE IMPACT OF THE PRINCIPIA

- IT WAS MATHEMATICALLY VERY CHALLENGING, PERHAPS IN SOME RESPECT, DUE TO NEWTON'S DISLIKE FOR HOOKE WITH WHOM HE WAS FEUDING SO HE WROTE IT AT SUCH A HIGH LEVEL THAT HOOKE COULD NOT UNDERSTAND IT.
- IN FACT, THE LEVEL OF THE MATHEMATICS IN IT WERE SO CHALLENGING THAT FEW COULD UNDERSTAND IT, SO IT FAILED TO GAIN MUCH TRACTION.
- ALEXANDER POPE WROTE: "NATURE AND NATURE'S LAWS LAY HID IN NIGHT. GOD SAID, 'LET NEWTON BE', AND ALL WAS LIGHT".
- IN A SURVEY OF THE ROYAL SOCIETY IN 2005 MEMBERS SAID THAT NEWTON HAD A GREATER CONTRIBUTION BOTH TO THE HISTORY OF SCIENCE AND TO HUMAN KIND THAN DID ALBERT EINSTEIN.
- MICHAEL HART, AN OXFORD FELLOW IN POLITICS, RANKS NEWTON 2ND ONLY TO MOHAMMED AS THE MOST INFLUENTIAL PERSON IN HISTORY.

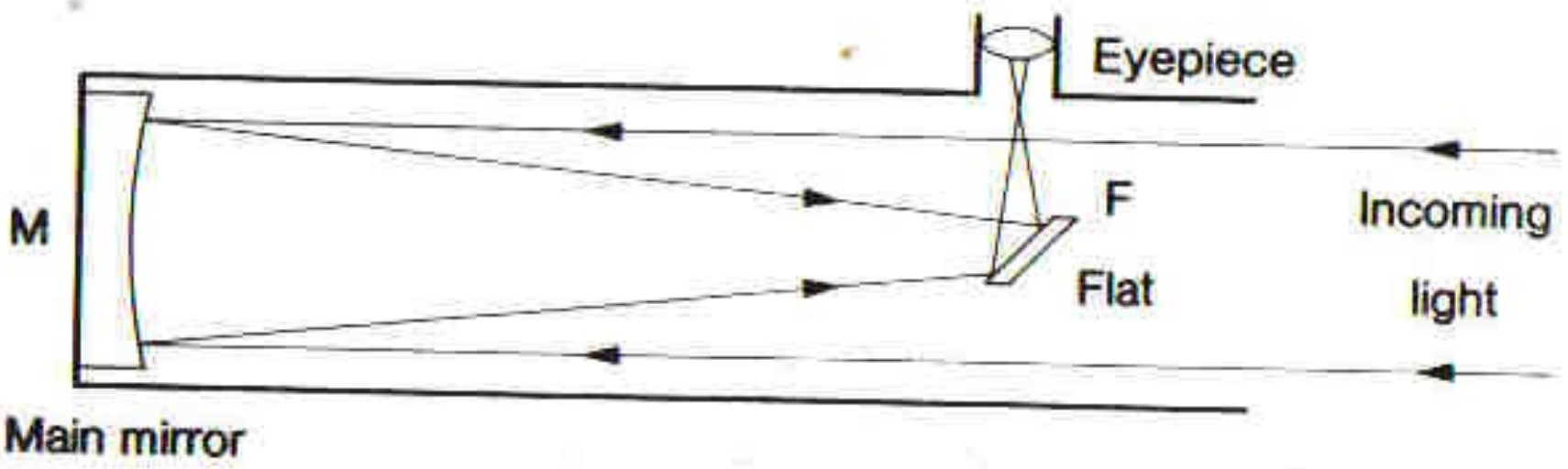
MORE ACCOLADES

- French mathematician Joseph-Louis Lagrange often said that Newton was the greatest genius who ever lived, and once added that Newton was also "the most fortunate, for we cannot find more than once a system of the world to establish."
- NEWTON, IN A LETTER TO HOOKE SAID, "If I have seen further it is by standing on the shoulders of Giants".
- SOME SAY THIS WAS A STAB AT HOOKE WHO WAS RATHER STOOPED, OTHERS SAY IT WAS AN HONEST SENTIMENT.

NEWTON'S OTHER CONTRIBUTIONS

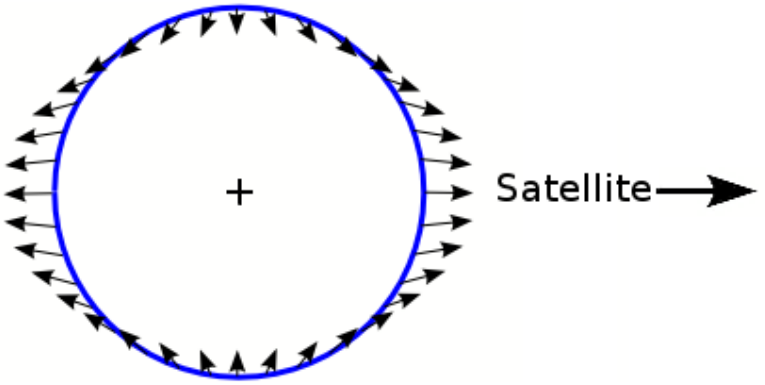
- DEVELOPED THE NEWTONIAN TELESCOPE
- WROTE A LARGE VOLUME ON OPTICS – STATED THAT WHITE LIGHT WAS SIMPLY A MIX OF ALL COLORS
- DESCRIBED THE PHENOMENON KNOWN AS CHROMATIC ABERRATION
- POSITED (INCORRECTLY) THE EXISTENCE OF A SUPERLUMINIFEROUS EITHER

NEWTONIAN TELESCOPE



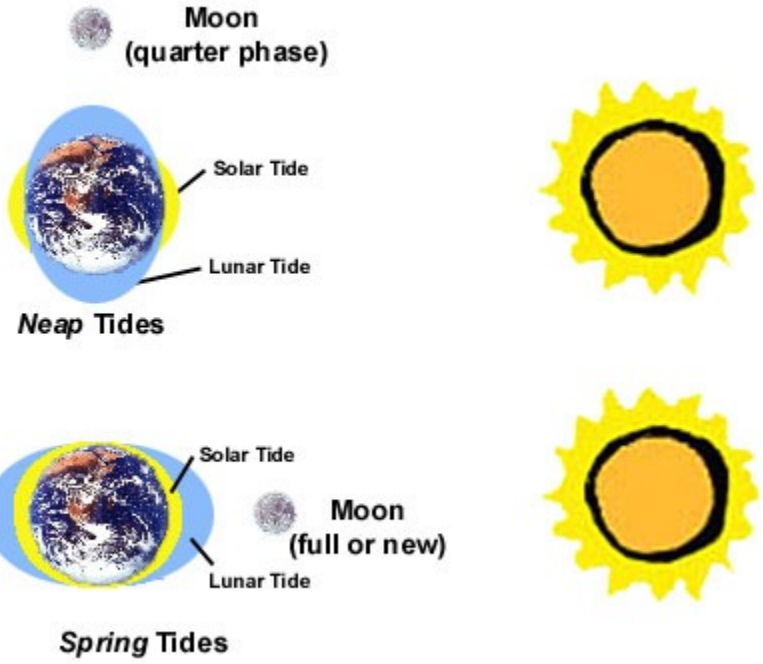
TIDES

- THE TIDE FORCE IS A DIFFERENTIAL FORCE
- $F_T = \text{const}/r^3$
- THEREFORE: THE MOON RAISES GREATER TIDES ON THE EARTH THAN THE SUN DOES BY ALMOST A FACTOR OF 2.
- THERE ARE 2 HIGH TIDES AND 2 LOW TIDES PER DAY.



TIDES

- SPRING TIDES – THE SUN AND THE MOON WORK TOGETHER TO RAISE EXTRAORDINARY HIGH AND LOW TIDES – NEW AND FULL MOON
- NEAP TIDES – THE SUN AND THE MOON RAISE OPPOSING TIDES TO RAISE EXTRAORDINARILY LOW HIGH TIDES AND EXTRAORDINARILY HIGH LOW TIDES – 1ST AND 3RD QUARTER MOON



TIDES

- THE HEIGHT OF A TIDE IS DETERMINED BY THE TOPOGRAPHY OF THE OCEAN BOTTOM AND THE SHORELINE
- HIGHEST TIDES OCCUR IF YOU HAVE A GENTLY SLOPING BOTTOM INTO AN INLET OR BAY
- THE HIGHEST TIDES ON THE EARTH ARE AT THE BAY OF FUNDY IN NOVA SCOTIA – AS HIGH AS 50 FEET

TIDES

- IF THE EARTH WERE COVERED BY DEEP WATER THE TIDE WOULD BE ABOUT 1.2 METERS
- THE EARTH'S BODY TIDE IS ABOUT 15 INCHES AT THE EQUATOR
- THE FRICTION CAUSED BY THE TIDAL MOTION SLOWS THE EARTH'S ROTATIONAL RATE DOWN BY ABOUT 1.5 MSEC/CENTURY
- CONSERVATION OF ANGULAR MOMENTUM CAUSES A SHIFT IN ANGULAR MOMENTUM TO THE MOON
- THE MOON IS MOVING AWAY FROM THE EARTH AND THE LENGTH OF THE MONTH IS INCREASING
- IN THE FAR FUTURE THE EARTH'S ROTATION WILL SLOW TO 47 DAYS, THE MONTH WILL LAST 47 DAYS AND THE EARTH AND MOON WILL KEEP THE SAME FACE TOWARD EACH OTHER