

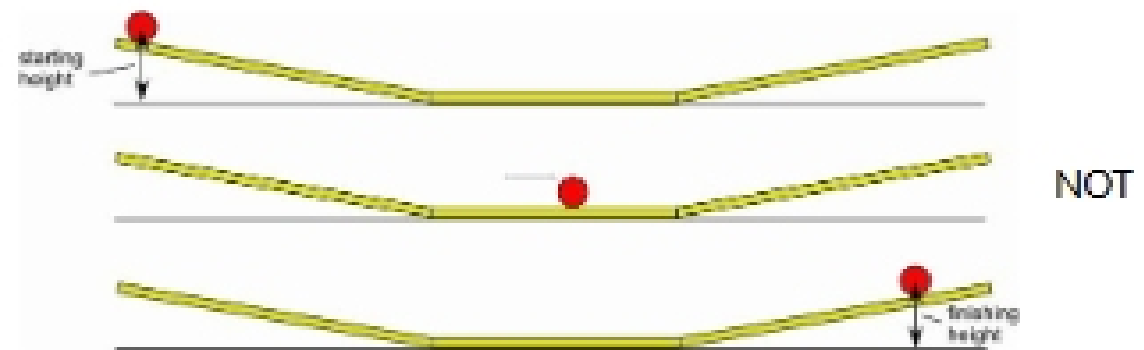
ASTRONOMY STUDY GUIDE 1

8: MODELS OF MOTION

1

- ANCIENT GREEK IDEAS ABOUT MOTION-> ARISTOTLE. MOTION WAS JUST SPEED. AMOUNT OF FORCE DETERMINES SPEED. SAYS THAT AIR HAS FORCE.
- EARTHLY/MUNDANE OBJECTS NATURALLY AT REST, HEAVENLY OBJECTS ARE ALWAYS MOVING
- A SPEAR IN A VACUUM WOULD INSTANTLY STOP.

-ARISTOTLE PREDICTED THAT HEAVIER OBJECTS FALL FASTER THAN LIGHTER OBJECTS. HE LET FALL A WOODEN AND IRON BALL. -"ARTIFICIAL" SITUATIONS WERE REASONABLE TO THE GREEKS



2

-GALILEO- EXPERIMENTS DURING 1589-1642 WHILE WRITING BOOK, DE MOTU. WORKED WITH INCLINED PLANES. ONLY MEASURED THE HEIGHTS, NOT SPEED OF THE BALLS.

- HE FOUND MAKING THE FLAT PART LONGER MADE THE BALL SLOW DOWN.
- ARISTOTLE PREDICTED AN INHERENT AND UNAVOIDABLE LOSS OF SPEED, BUT GALILEO COULDN'T FIND THAT.

-CONCLUDED THAT IN ABSENCE OF OUTSIDE FORCES, AN OBJECT AT REST= REST. MOTION= CONSTANT SPEED, STRAIGHT LINE.

3

-GALILEO THEN MADE STRAIGHT SLOPES. SAW THAT THE BALL WENT FURTHER WITH MORE TIME.

-RATE OF INCREASE OF SPEED IS ACCELERATION. **ACCELERATION** IS ALSO THE RATE OF CHANGE OF VELOCITY. **VELOCITY**= COMBINATION OF SPEED AND DIRECTION OF MOTION.

-LAW OF INERTIA= WITHOUT OUTSIDE FORCES, THE ACCELERATION OF AN OBJECT IS ZERO.

4

-GALILEO NOTICED THAT WEIGHT DID NOT MATTER WITH ACCELERATION.

-DROPPED WOOD AND IRON BALL. ARISTOTLE PREDICTED IRON BALL WOULD DROP FIRST. GALILEO PREDICTED SAME.

-SOMETIMES WOOD HIT FIRST, SOMETIMES IRON HIT FIRST.

-UNIVERSALITY OF FREE FALL= OBJECTS IN FREE FALL ACCELERATE DOWNWARD AT A RATE THAT IS THE SAME FOR ALL OBJECTS. RATE IS 9.8 M PER SEC PER SEC.

5

-NEWTON MADE **GALILEO'S FIRST LAW OF INERTIA** (ACCELERATION, NOT SPEED). WHEN TOTAL FORCE OF AN OBJECT IS ZERO, ACCELERATION IS ZERO.

-FORCE IS PROPORTIONAL AND IN DIRECTION OF ACCELERATION. 2X FORCE= 2X ACCELERATION, 3X=3X, ETC.

-SECOND LAW OF MOTION= IF TOTAL FORCE F ON AN OBJECT PRODUCES AMOUNT OF ACCELERATION A, THEN... F=MA. M IS ONLY ON OBJECT.

- LARGER MASS NEEDS MORE FORCE FOR A CERTAIN AMOUNT OF ACCELERATION
- THE ADDITION LAWS= TWO FORCES, F1 AND F2, TOTAL FORCE IS F1+F2. TWO OBJECTS WITH MASSES M1 AND M2 ARE CONNECTED, MAKES M1+M2.
- ADDITION LAWS HELP MEASURE FORCE AND MASS WITH SPRING AND WEIGHT BALANCES. WITHOUT IT, NEWTON'S SECOND LAW IS EMPTY.
- UNIT OF MASS IS KILOGRAM, FROM PARIS. NEWTON IS ¼ A POUND, AND IS THE FORCE THAT CAUSES ONE KILOGRAM TO ACCELERATE AT ONE M PER SEC PER SEC

6

- THIRD LAW OF MOTION= IF OBJECT A EXERTS A FORCE ON B, THEN B EXERTS EQUAL AND OPPOSITE FORCE ON A.
- INTERNAL FORCES CANCEL OUT ON SUM OF FORCES ON A SYSTEM (EX: YOU CAN'T PICK YOURSELF UP BY YOUR BOOTSTRAPS).
- EX: HORSE AND CART: HORSE AND ROAD PUSH ON EACH OTHER. THE FORCE EXERTED BY THE ROAD MAKES THE SYSTEM GO.
- EX: HOW A ROCKET WORKS: ROCKET PUSHES AGAINST EXHAUST, BEST WITH NO SURROUNDING AIR.

9: MODELS OF MOTION

1

- NEWTON'S ADVANTAGES OVER THE CONTEMPORARIES:
 - 1)UNDERSTOOD THAT IT WAS ACCELERATION THAT MAKES THE FORCE
 - 2)INVENTED CALCULUS, CALCULATES MAGNITUDE AND DIRECTION OF ACCELERATION OF PLANET. INVERSELY PROP TO SQUARE OF PLANET'S DISTANCE FROM SUN.
- NEWTON: PLANETS WITH ELLIPTICAL ORBITS, WITH KEPLER'S LAWS- ACCELERATION ALWAYS POINTS DIRECTLY TOWARDS SUN. MAGNITUDE= $1/(\text{DISTANCE})^2$

2

- NEWTON CALCULATED DIRECTION AND MAGNITUDE MOON'S ORBIT AROUND EARTH. ACCELERATION WAS TO EARTH, $1/3600$ OF ACCELERATION OF AN OBJECT FALLING NEAR EARTH. MOON'S ACCELERATION IS SMALL.
- MOON IS 60 RADII AWAY AND ALSO 60X FAR AWAY FROM CENTER OF EARTH AS AN APPLE WOULD BE. BOTH THE MOON AND APPLE SHOW $1/(\text{DISTANCE})^2$

3

- NEWTON FOUND OUT THAT THERE WERE MULTIPLE GRAVITATIONAL ACCELERATIONS, EVERYTHING ATTRACTS EVERYTHING.
- THE FORCE OF GRAVITY ON AN OBJECT ON EARTH IS PROPORTIONAL TO THE MASS OF THE OBJECT (FORCE (F) PROPORTIONAL TO MASS OF AND ALSO (m). $F = G \frac{mM}{D^2}$ TO (M),
- G= #, NEWTON'S GRAVITATIONAL CONSTANT, EXTREMELY SMALL (SO ONE
- OF THE MASSES NEEDS TO BE LARGE FOR FORCE OF GRAVITY TO BE NOTICED).
- GRAVITATIONAL ATTRACTION OF EARTH IS SMALLER FOR OBJECTS FARTHER FROM EARTH, NEVER DISAPPEARS.

4

- NEWTON'S THEORY OF GRAVITY EXPLAINED THESE:

- 1) FALLING OBJECTS ON EARTH
- 2) MOTIONS OF HEAVENLY BODIES (MOON, PLANETS)
- 3) OCEAN TIDE MOVEMENT

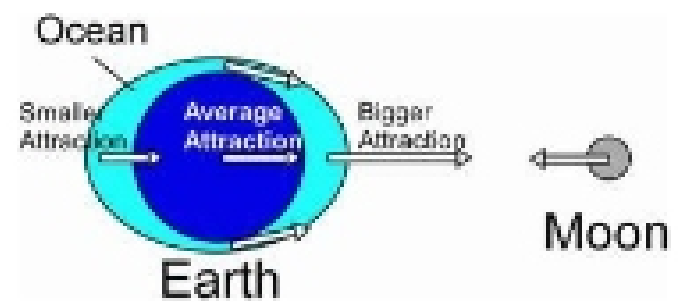
-KEPLER= FORCE ATTRACTS EACH PLANET TO THE SUN. NEWTON EXPLAINS KEPLER'S LAWS ACTS ON ALL OBJECTS.

-GALILEO- ALL OBJECTS FALL SIMILARLY, COMBINE LAW OF FORCE AND MASS ($F=MA$), WITH LAW OF GRAVITY.

-LAW OF FORCE AND MASS SAYS THAT BIG OBJECTS NEED MORE FORCE FOR GIVEN ACCELERATION RATE

-LAW OF UNIVERSAL GRAVITATION SAYS THAT BIG OBJECTS GET MORE FORCE FOR SAME ACCELERATION RATE

-ALL MOONS ATTRACT TO THEIR PLANETS BY GRAVITY. ALL PLANETS FALL TOWARD THE SUN. TIDES ARE BECAUSE OF MOON'S DIFFERENT AMOUNTS OF GRAVITY. OCEANS UNDER MOON= STRONGEST, OCEANS OPPOSITE MOON= WEAKEST



5

-NEWTON'S THEORY OF GRAVITY CORRECTED KEPLER'S LAW OF PLANETARY MOTION:

- 1) B/C OF ACTION AND REACTION, SUN WOBBLER
- 2) PLANETS ARE ATTRACTED TO EACH OTHER AND SUN

-NEWTON'S= EARTH AND MOON MOVE AROUND A POINT, AROUND THE SUN.

-B/C OF NEWTON'S LAW OF ACTION AND REACTION, ORBITING OBJECTS ACCELERATE TOWARDS EACH OTHER. BIGGER OBJECTS MOVE LESS. SUN MOVES VERY LITTLE.

-WOBBLE USED TO DETECT PLANETS AROUND STARS. WOBBLE MODIFIES KEPLER'S THIRD LAW, NOT T^2/R^3 , BUT $MTOTAL^2/R^3$. $MTOTAL$ IS MASS OF SUN+PLANET.

-NEPTUNE WAS DISCOVERED B/C GRAVITY DISTURBED URANUS'S ORBIT.

6

-SPACECRAFTS= SPEEDS BELOW ESCAPE VELOCITY= ELLIPSE PATHS

-SUB-ORBITAL FLIGHT- OBJECT MOVING NEAR EARTH'S SURFACE, < 5 M/SEC, PATH= ELLIPSE

-CIRCULAR LOW- EARTH ORBIT, > 5 M/SEC, PATH= CIRCLE. SPACECRAFT ACCELERATES AT THE SAME RATE AS FALLING NEAR GROUND.

-TRANSFER ORBIT- BETWEEN 5-7 MILES/SEC, PATH= ELLIPSE OVER WHOLE EARTH. FARTHER AWAY FROM EARTH= SLOWER.

-ESCAPE TRAJECTORY- > 7 M/SEC= NEVER RETURN TO EARTH. FORMS HYPERBOLA.

> 7 M/SEC= **ESCAPE VELOCITY**

-SLOWER GRAVITY WHEN FARTHER FROM THE EARTH, LOWER GRAVITY AS WELL.

-INTERCONTINENTAL BALLISTIC MISSILE= ELLIPSE, FOLLOWS KEPLER'S LAWS.

-ARTIFICIAL SATELLITES STAY UP BECAUSE THE EARTH CURVES OUT.

10: OVERVIEW OF THE SOLAR SYSTEM

1

-THE INNER PLANETS ->

-ASTRONOMICAL UNITS (AU). EARTH TO SUN= 1 AU

