

GRAVITATION  $G = 6.67 \times 10^{-11} [\text{Nm}^2/\text{kg}^2]$

1. A) SUPERMAN,  $m = 100 \text{ kg}$ , STANDS TWO METERS FROM LOIS LANE, WHOSE MASS IS  $45 \text{ kg}$ . ASSUMING THAT ONLY GRAVITATIONAL FORCES ARE ACTING, FIND THE FORCE OF ATTRACTION BETWEEN THE MAN OF STEEL AND LOIS.
  - B) NOW, THEY APPROACH EACH OTHER UNTIL THEY ARE ONE METER APART. FIND THE PRESENT FORCE OF GRAVITATIONAL ATTRACTION.
  - C) BY WHAT FACTOR DID THE FORCE OF ATTRACTION INCREASE AS THEY APPROACHED EACH OTHER? ( $7.5 \times 10^{-8}$ ,  $3 \times 10^{-7}$ , 4)
2. THE MOON HAS  $M = 7.34 \times 10^{22} \text{ kg}$  AND  $R = 1.738 \times 10^6 \text{ m}$ .
  - A) FIND THE LUNAR GRAVITATIONAL ACCELERATION.
  - B) MR. HARVIE WEIGHS  $750 \text{ N}$  ON EARTH. FIND HIS MASS.
  - C) DESIRING TO LOSE WEIGHT, HE FLIES TO THE MOON. FIND HIS LUNAR WEIGHT. ( $1.62 \text{ m/s}^2$ ,  $75 \text{ kg}$ ,  $121.5 \text{ N}$ )
3. ON THE MOON, TRAVIS THROWS A BASEBALL STRAIGHT UP AT  $12.34 \text{ m/s}$ . FIND ITS MAXIMUM ELEVATION. ( $47 \text{ m}$ )
4. ON THE MOON, ASTRONAUT ALAN SHEPARD HIT A GOLF BALL SO THAT ITS INITIAL VELOCITY WAS  $67.5 \text{ m/s}$  AT  $36.87^\circ$ 

$x_0 =$	$y_0 =$
A) FILL IN $v_{0x} =$	$v_{0y} =$
THE CHART: $a_x =$	$a_y =$

  - B) FIND THE TOTAL TIME AIRBORNE.
  - C) FIND THE BALL'S RANGE. ( $0, 0, 54, 40.5, 0, -1.62, 50, 2700$ )
5. PLAYING LUNAR BASKETBALL, JEFF,  $m = 80 \text{ kg}$ , BENDS HIS LEGS  $.5 \text{ m}$  AND THEN EXERTS AN UPWARD FORCE OF  $2400 \text{ N}$ , AFTER WHICH HE ZOOMS INTO THE SKY. FIND:
  - A) HIS UPWARD ACCELERATION AS HE STRAIGHTENS HIS LEGS. ( $28.4 \text{ m/s}^2$ )
  - B) VELOCITY WITH WHICH HE LEAVES THE GROUND. ( $5.32 \text{ m/s}$ )
  - C) HIS MAXIMUM ELEVATION. ( $8.74 \text{ m}$ )
6. CLIMBING MOUNTAINS ON THE MOON, ALEC,  $m = 75 \text{ kg}$ , LOSES HIS GRIP AND FALLS FREELY FOR  $25 \text{ m}$  UNTIL THE ROPE IS NO LONGER SLACK. THE ROPE NOW STRETCHES TWELVE PERCENT OF ITS LENGTH TO BRING ALEC TO REST.

FIND :

- A) HIS VELOCITY AFTER THE FREE FALL. ( $-9 \text{ m/s}$ )  
 B) HIS ACCELERATION AS THE ROPE TIGHTENS. ( $13.5 \text{ m/s}^2$ )  
 C) THE TENSION IN THE ROPE. ( $1134 \text{ N}$ )

7. MR. HARVIE,  $m = 75 \text{ KG}$ , JUMPS OFF THE GYMNASIUM IN AN ATTEMPT TO MOVE THE EARTH, WHOSE MASS IS  $5.98 \times 10^{24} \text{ KG}$  AND WHOSE RADIUS IS  $6.38 \times 10^6 \text{ m}$ .

- A) FIND THEIR EXACT GRAVITATIONAL FORCE OF ATTRACTION.  
 B) FIND MR. HARVIE'S EXACT ACCELERATION.  
 C) FIND THE EARTH'S ACCELERATION.  
 D) FIND THE DISTANCE TRAVELED BY EACH OBJECT IN THREE SECONDS. ( $735 \text{ N}$ ,  $9.8 \text{ m/s}^2$ ,  $1.23 \times 10^{-22}$ ,  $44$ ,  $5.5 \times 10^{-22}$ )

8. VENUS ORBITS THE SUN AT AN AVERAGE DISTANCE OF  $1.08 \times 10^{11} \text{ m}$ . THE SUN'S MASS IS  $2 \times 10^{30} \text{ KG}$ . FIND :

- A) THE ORBITAL SPEED OF VENUS. ( $35145 \text{ m/s}$ )  
 B) THE TIME FOR VENUS TO ORBIT THE SUN. ( $1.93 \times 10^7 \text{ SEC}$ )

9. MARS TAKES  $5.936 \times 10^7$  SECONDS TO ORBIT THE SUN, WHOSE MASS IS  $2 \times 10^{30} \text{ KG}$ . FIND THE RADIUS OF MARS' ORBIT. ( $2.28 \times 10^{11} \text{ m}$ )

10. EUROPA, A MOON OF JUPITER, ORBITS HER PLANET IN  $7 \times 10^6$  SECONDS. THE RADIUS OF EUROPA'S ORBIT IS  $5.4 \times 10^9 \text{ m}$ . FIND THE MASS OF JUPITER. ( $1.9 \times 10^{27} \text{ KG}$ )

11. THE SPACE SHUTTLE ORBITS THE EARTH AT AN ALTITUDE OF  $320 \text{ km}$ . THE EARTH HAS  $R = 6380 \text{ km}$  AND A MASS OF  $5.98 \times 10^{24} \text{ KG}$ . FIND THE :

- A) RADIUS OF ITS ORBIT    B) PERIOD OF ITS ORBIT  
 C) NUMBER OF TIMES THAT THE SHUTTLE ORBITS THE EARTH IN ONE DAY. ( $6.7 \times 10^6 \text{ m}$ ,  $5456 \text{ SEC}$ ,  $15.8 \text{ TIMES}$ )

12. A SATELLITE ORBITS THE EARTH THREE TIMES PER DAY. THE EARTH HAS  $R = 6380 \text{ km}$  AND  $M = 5.98 \times 10^{24} \text{ KG}$ .

- FIND THE : A) PERIOD OF ITS ORBIT ( $28800 \text{ SEC}$ )  
 B) RADIUS OF ITS ORBIT ( $2.03 \times 10^7 \text{ m}$ )  
 C) ALTITUDE OF THE SATELLITE ( $13932 \text{ km}$ )

## INTUITIONS FOR GRAVITY

### A. INVERSE SQUARE LAW $g_{\text{PLANET}} = GM/R^2$

ELENA,  $m = 55 \text{ kg}$ , VISITS SEVERAL NEW PLANETS. FIND THE ACCELERATION DUE TO GRAVITY ON EACH PLANET AND HER WEIGHT THERE.

1. WODEN, WHICH HAS FOUR TIMES THE MASS OF EARTH AND THE SAME RADIUS AS EARTH. ( $40 \text{ m/s}^2$ ,  $2200 \text{ N}$ )
2. FRIGG, WHICH HAS .3 TIMES THE MASS OF EARTH AND THE SAME RADIUS. ( $3 \text{ m/s}^2$ ,  $165 \text{ N}$ )
3. THOR, WHICH HAS ONE-FIFTH THE MASS OF EARTH AND ONE-SIXTH THE RADIUS OF EARTH. ( $72 \text{ m/s}^2$ ,  $3960 \text{ N}$ )
4. TIW, WHICH HAS THE SAME MASS AS EARTH AND FIVE TIMES THE RADIUS. ( $.4 \text{ m/s}^2$ ,  $22 \text{ N}$ )
5. VALKYRIE, WHICH HAS THE SAME MASS AS EARTH BUT ONLY .4714 TIMES THE RADIUS OF EARTH ( $45 \text{ m/s}^2$ ,  $2475 \text{ N}$ )
6. VALHALLA, WHICH HAS 63 TIMES THE MASS OF EARTH AND THREE TIMES ITS RADIUS. ( $70 \text{ m/s}^2$ ,  $3850 \text{ N}$ )

### B. KEPLER'S THIRD LAW $\left(\frac{T^2}{R^3}\right)_A = \left(\frac{T^2}{R^3}\right)_B$

THE LAW OF HARMONY

1. JUPITER ORBITS THE SUN AT A MEAN DISTANCE OF 5.2 A.U. FIND THE PERIOD OF ITS ORBIT. (11.86 YEARS)
2. MERCURY ORBITS THE SUN AT MEAN DISTANCE OF .387 A.U. FIND THE PERIOD OF ITS ORBIT. (.24075 YEARS)
3. NEPTUNE ORBITS THE SUN EVERY 164.8 YEARS. FIND THE MEAN DISTANCE BETWEEN THE SUN AND NEPTUNE. (30 A.U.)
4. VENUS ORBITS THE SUN EVERY 224.7 DAYS.
  1. CONVERT THE PERIOD TO YEARS. (.6152 YRS)
  2. FIND THE RADIUS OF ITS ORBIT. (.723 A.U.)
5. THE MOON,  $3.8 \times 10^5 \text{ km}$  FROM EARTH, ORBITS GAEA EVERY 27.3 DAYS. A SATELLITE TAKES 13.65 DAYS TO ORBIT THE EARTH. FIND THE RADIUS OF ITS ORBIT. ( $2.394 \times 10^5 \text{ km}$ )

TORREY PINES HIGH SCHOOL  
OFFICIAL PHYSICS FIGHT SONG

79

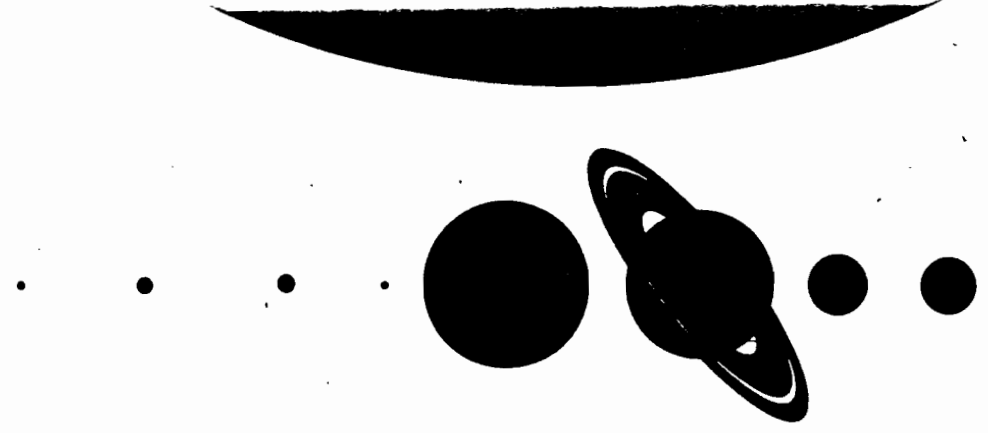
WE ARE FRIENDS OF ISAAC NEWTON,  
FIGHTING FOR THE MASS AND FORCE.  
M TIMES A GIVES FORCE THAT MEANS  
WE GO FASTER, WE GO.

STREAKING UP INTO THE HEAVENS,  
HIGHER UP INTO THE SKY.  
BUT GRAVITATION PULLS US BACK  
SO ELLIPSES WE DO MAKE.

AS WE CRUISE AROUND GAEA,  
WE COME NEAR AND GO FAR.  
FAST AND SLOW WE ZOOM AROUND  
OUR PLANETARY HOME.

WHEN WE MEASURE THE ENERGY,  
THE KINETIC STARTS TO DIE.  
BUT POTENTIAL GROWS, POTENTIAL GROWS  
AND THAT'S THE WAY IT GOES.

G, RAH, RAH, RAH, M, RAH, RAH, RAH,  
R, RAH, RAH, RAH, SQUARED, RAH, RAH, RAH,  
G, M, R, SQUARED, FIGHT, FIGHT, FIGHT!



	MERCURY	VENUS	EARTH	MARS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO	
1	MAXIMUM DISTANCE FROM SUN (MILLIONS OF KILOMETERS)	69.7	109	152.1	249.1	815.7	1,507	3,004	4,537	7,375
2	MINIMUM DISTANCE FROM SUN (MILLIONS OF KILOMETERS)	45.9	107.4	147.1	206.7	740.9	1,347	2,735	4,456	4,425
3	MEAN DISTANCE FROM SUN (MILLIONS OF KILOMETERS)	57.9	108.2	149.6	227.9	778.3	1,427	2,869.6	4,496.6	5,900
4	MEAN DISTANCE FROM SUN (ASTRONOMICAL UNITS)	.387	.723	1	1.524	5.203	9.539	19.18	30.06	39.44
5	PERIOD OF REVOLUTION	88 DAYS	224.7 DAYS	365.26 DAYS	687 DAYS	11.86 YEARS	29.46 YEARS	84.01 YEARS	164.8 YEARS	247.7 YEARS
6	ROTATION PERIOD	59 DAYS	-243 DAYS RETROGRADE	23 HOURS 56 MINUTES 4 SECONDS	24 HOURS 37 MINUTES 23 SECONDS	9 HOURS 50 MINUTES 30 SECONDS	10 HOURS 14 MINUTES	-11 HOURS RETROGRADE	16 HOURS	6 DAYS 9 HOURS
7	ORBITAL VELOCITY (KILOMETERS PER SECOND)	47.9	35	29.8	24.1	13.1	9.6	6.8	5.4	4.7
8	INCLINATION OF AXIS	<28°	3°	23°27'	23°59'	3°05'	26°44'	82°5'	28°48'	?
9	INCLINATION OF ORBIT TO ECLIPTIC	7°	3.4°	0°	1.9°	1.3°	2.5°	.8°	1.8°	17.2°
10	ECCENTRICITY OF ORBIT	.206	.007	.017	.093	.048	.056	.047	.009	.25
11	EQUATORIAL DIAMETER (KILOMETERS)	4,880	12,104	12,756	6,787	142,800	120,000	51,800	49,500	6,000 (?)
12	MASS (EARTH = 1)	.055	.615	1	.108	317.9	95.2	14.6	17.2	.1 (?)
13	VOLUME (EARTH = 1)	.06	.88	1	.15	1,316	755	67	57	.1 (?)
14	DENSITY (WATER = 1)	5.4	5.2	5.5	3.9	1.3	.7	1.2	1.7	?
15	OBLATENESS	0	0	.003	.009	.06	.1	.06	.02	?
16	ATMOSPHERE (MAIN COMPONENTS)	NONE	CARBON DIOXIDE	NITROGEN, OXYGEN	CARBON DIOXIDE, ARGON (?)	HYDROGEN, HELIUM	HYDROGEN, HELIUM	HYDROGEN, HELIUM, METHANE	HYDROGEN, HELIUM, METHANE	NONE DETECTED
17	MEAN TEMPERATURE AT VISIBLE SURFACE (DEGREES CELSIUS) S = SOLID, C = CLOUDS	350(S) DAY -170(S) NIGHT	-33 (C) 480 (S)	22 (S)	-23 (S)	-150 (C)	-180 (C)	-210 (C)	-220 (C)	-230(?)
18	ATMOSPHERIC PRESSURE AT SURFACE (MILLIBARS)	10 <sup>-4</sup>	90,000	1,000	6	?	?	?	?	?
19	SURFACE GRAVITY (EARTH = 1)	.37	.88	1	.38	2.64	1.15	1.17	1.18	?
20	MEAN APPARENT DIAMETER OF SUN AS SEEN FROM PLANET	1°22'40"	44'15"	31'59"	21'	6'09"	3'22"	1'41"	1'04"	49"
21	KNOWN SATELLITES	0	0	1	2	13	10	5	2	0
22	SYMBOL	♿	♀	♁	♂	♃	♄	♅	♆	♇