Physics 172 Winter Quarter 1982

FIRST MIDTERM

Name (Print) KEY

Name (Sign) GRADER – BOB WHEELER S.S. No. AVE – 17

Discussion Instructor: Abbott Allen
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Problem No. 1

(a) Calculate the electric force between two positive charges of 6.0 μC and 9.0 μC a distance of 3 centimeters apart. 5×10^2 N

(b) Calculate the gravitational force between a 100 kg man and a 1.50×10^3 kg truck, if they are 10.0 meters apart. 1.00×10^{-7} N

(c) Find the acceleration of an electron in an electric field of 1.30×10^3 N/C.
2.3×10^{14} m/s^2

(d) Find the value of $\vec{g}$ at a distance of 8000 miles above the earth's surface.
1.1 N/kg

(e) The distance from earth to the sun is 93,000,000 miles. Find the mass of the sun. 1.9×10^{30} kg

PROBLEM 1 — Bob Wheeler

a) Force is : $F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$ $\quad \mu = 10^{-6}$

$$F = \frac{(8.99\times10^9\ N\cdot m^2/C^2)(6.0\times10^{-6}\ C)(9.0\times10^{-6}\ C)}{(3\times10^{-2}\ m)^2} = \boxed{5\times10^2\ N}$$

1 significant figure since 3 cm has only 2 significant figure

b) Force is : $F = G\frac{m_1 m_2}{r^2}$

$$F = \frac{(6.67\times10^{-11}\ N\cdot m^2/kg^2)(10\ kg)(1.50\times10^3\ kg)}{(10.0\ m)^2} = 1.00\times10^{-7}\ N$$

either $\boxed{1.00\times10^{-7}\ N}$ or $\boxed{1.000\times10^{-7}\ N}$ is correct

c) Forces : $F = ma$ and $F = Eq$ hence

$$a = \frac{Eq}{m} \quad \text{so}$$

$$a = \frac{(1.30\times10^3\ N/C)(1.6\times10^{-19}\ C)}{(9.1\times10^{-31})\ kg} = \boxed{2.3\times10^{14}\ \frac{m}{sec^2}}$$

since N/kg is dimensionally equivalent to m/sec^2 either N/kg or m/sec^2 correct

2 significant figures since $1.6\times10^{-19}C$ has 2 significant figures

d) if 8000 miles above surface, then 8000 + 4000 miles from center

convert 12000 miles to meters

$$12000\ miles \cdot \frac{5280\ ft}{mile} \cdot \frac{0.30\ m}{ft} = 1.90\times10^7\ meters$$

now $g = \frac{GM_{earth}}{r^2}$ or $g = \frac{(6.67\times10^{-11}\ N\cdot m^2/kg^2)(6.0\times10^{24}\ kg)}{(1.90\times10^7\ m)^2}$

$g = \boxed{1.1\ N/kg}$ or $\boxed{1.1\ m/sec^2}$ 2 significant figures since $0.30\ m = 1\ ft$ has 2 significant figures

c) You could solve this problem with Kepler's law $T^2 = Cr^3$ if you know what C is.

Here is the way to solve it without Kepler's law:

The force needed to keep the earth in circular orbit about the sun is

$F = M_e \omega^2 r$ where ω is the angular velocity

The force that holds the earth in orbit is gravity

$$F = \frac{G M_e M_s}{r^2}$$

Setting these forces equal we have

$M_e \omega^2 r = \frac{G M_e M_s}{r^2}$ and solving for M_s

we get $M_s = \frac{\omega^2 r^3}{G}$

$\omega = \frac{2\pi}{T}$ where T is the period of the earth's rotation

$T = 365 \text{ Days} \cdot \frac{24 \text{ hours}}{\text{Day}} \cdot \frac{3600 \text{ sec}}{\text{hour}} = 31536000 \text{ Sec}$

hence $\omega = 1.9923649 \times 10^{-7} \frac{\text{rad}}{\text{sec}}$

now we know $r = 93,000,000$ miles, we need r in meters

$93000000 \text{ miles} \cdot \frac{5280 \text{ ft}}{\text{mile}} \cdot \frac{0.30 \text{ m}}{\text{ft}} = 1.47 \times 10^{11} \text{ m}$

so $$M_s = \frac{\omega^2 r^3}{G} = \frac{\left(1.9923649 \times 10^{-7} \frac{\text{rad}}{\text{sec}}\right)^2 (1.47 \times 10^{11} \text{ m})^3}{(6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2/\text{kg}^2)}$$

hence

$\boxed{M_s = 1.9 \times 10^{30} \text{ kg}}$ with 2 significant figures since in converting 93000000 miles to meters we used 0.30 m = 1 ft and 0.30 has only 2 significant figures

on parts d and e, a few people used the English units, the correct answers are

d) 3.7 ft/sec^2

e) 1.3×10^{29} slugs

Point breakdown

5 points for each part

Having ±1 Extra significant figure	-1
no units	-1
wrong units	-2
±1 in the exponent	-1
wrong exponent	-2

Statistics

Total Tests	455
mean score	17
STD DEV	4.5