XF.0 107

Physics 107 (Kaldon-23825) **Name** ______________________________

WMU - Spring 2001
Exam 0F0 - 2×000,000 points Section: **10a** A to C **10b** D to F **10c** G to K **10d** L to N **10e** O to R **10f** S to Z

Rev. 4/16/99F·11/23/03Su

State Any Assumptions You Need To Make -- Show All Work -- Circle Any Final Answers
Use Your Time Wisely - Work on What You Can - Be Sure to Write Down Equations
BOLDFACE Variables Are Vectors - Feel Free to Ask Any Questions
Numbers Like 1 m/s Should NOT Be Considered 1 Significant Figure
Non-Numeric Problems Should Be Short Answers!

Dr. Phil's Terrible All-in-One Megadeth Roller Coaster Ride Problem (10,000 points each)

1.)(a) A cable pulls the cars of a roller coaster up a 53° incline at 1.00 m/s. If the top of the first hill is 30.0 m high, how long does it take to reach the top? *Hint: long means time here.*

(b) Does the cable have to support the entire weight of the cars? *Draw a free body diagram first.*

(c) One of the roller coaster cars has a mass of 200. kg. What is the *change* in it's P.E. from the bottom to the top of the first hill? … the K.E.?

(d) How much power must the motor have that pulls that cable? *Hint: If you started from the top of this page, you've already calculated the pieces you'll need to get an answer.*

(e) If the roller coaster drops all the way back to ground level at a 60° angle, can it reach a speed of 25.0 m/s at the bottom of the hill? Assume no friction.

(f) In the loop-the-loop section, the cars are going at 10.0 m/s at the top of the loop. Is a 10.0 m radius for the loop big enough so that the centripetal acceleration is greater than "g" at the top of the loop? *If $a_c < g$, then the cars aren't going fast enough – gravity pulls the cars off of the track and they fall instead of looping the loop.*

(g) If a girl on the roller coaster is holding onto a hotdog with a mass of 0.0500 kg, what is the gravitational attraction between the hotdog and the Moon a quarter of a million miles away? ($m_{MOON} = 7.36 \times 10^{22}$ kg ; distance = 3.8×10^8 m)

(h) A huge lighted sign advertising the roller coaster consumes 10.0 kW of 125 V electricity. Find the current, the resistance of the load, and how much energy it uses in five minutes.

(i) At a height of 15.0 m and traveling horizontally at 10.0 m/s, a kid leans over the edge of the car and "loses his lunch". Why are you safe if you stand on the ground directly below the kid?

(j) Where should you NOT stand? *(Draw a sketch and calculate).*

(k) Looking up, a rider sees the Moon hanging up in the sky. If the roller coaster was built on the Moon, where gravity is one-sixth that of the Earth, how much higher would that first 30.0 m hill have to be to get the same velocity coming down? Why?

(l) The engine that hauls the cars up the first hill runs at 23% efficiency, with the hot and cold reservoirs at 300°C and 30°C respectively. How good of an engine is this?

(m) Lightning strikes a tree 1.00 kilometer from the roller coaster. Do you see the flash or hear the thunder first? Why? Approximately how many seconds will it take the sound to travel 1.00 km? *Assume T = 20°C.*

(n) A kid 1.00 m behind you shrieks at 100 dB. At a distance of 10.0 m, the sound is 1/100th as loud. What dB is the kid's shriek at 10.0 m?

(o) Another kid on the roller coaster has a helium balloon they bought in the morning when it was 20°C. How much bigger is the balloon when the temperature reaches 30°C in the afternoon?

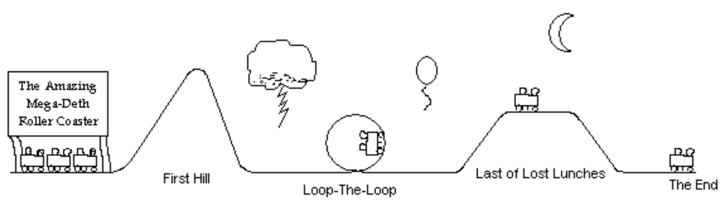
(p) At the end of the ride a friction brake is used to stop the cars, basically a piece of steel sliding on the rails. Which is important here, static or kinetic friction? Why?

(q) For a 200 kg car traveling at 5.00 m/s on level track, how far will the car slide before it comes to a stop if the coefficient of friction is 0.200? *Hint: This is a nasty problem. Find the friction force first, then use Newton's 2nd law.*

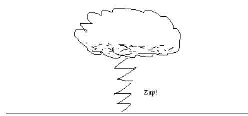
(r) If half the car's kinetic energy goes into heating a 4.00 kg block of steel, how much will the temperature of the block rise?

~~(s) At 5 m/s, what is the angular velocity of the wheels, if they are 10cm (0.1m) in radius?~~

(t) While the car is still going 5.00 m/s to the east, a ladybug lands and starts walking south at 1.00 m/s. Find the vector velocity $\vec{v}$ of the ladybug, relative to the Earth. *Use θ = 0° for east.*



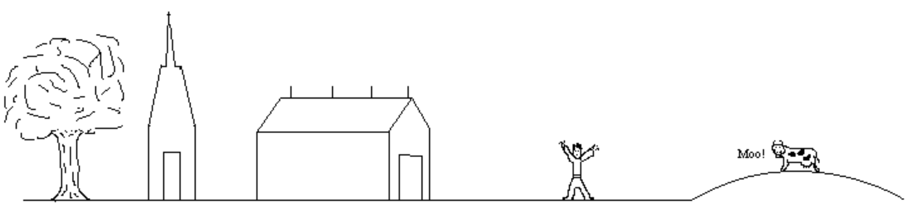
Shocking (50,000 points)



2.) A spark will jump a gap in air, if the electric field exceeds $E = 3 \times 10^6$ V/m. If lightning jumped in a *straight* path between the cloud and the ground, then we could figure out the potential difference between a cloud that is 1.00 km (1000 m) above the ground. (a) Find V (or we could call it ΔV).

(b) This cloud had -5.00 C of charge along its bottom, 1000 m above the ground. Suppose a charge +Q is induced in the surface of the earth directly below the cloud, that is equal and opposite to the charge of the cloud. Find the strength of the electric force, F_E, between the earth and the cloud, and explain whether the force is attractive or repulsive.

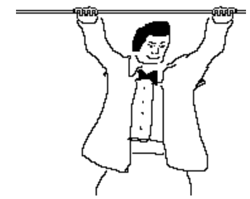
(c) One of the things that we didn't study is something called Gauss' Law, which allows us to calculate the relationships between an Electric Field, E, and a grouping of charges in a particular shape. One of the consequences of Gauss' Law is that charge tends to accumulate on sharp tips, rather than on long sides of things. The E-field is a maximum at the tip, too. Why would this make it more likely for lightning to hit trees, church steeples, people standing out in fields, lightning rods on the roof of a barn and cows grazing on a hilltop?



(d) Suppose 1.37 C of charge is moved in a lightning bolt in 0.25 seconds. What is the current, I ?

(e) If the potential difference between the cloud and the ground was 100,000,000 volts, how much power was there in the lightning bolt in part (d)?

The Last Physics Problem for Mr. Bond (30,000 points)

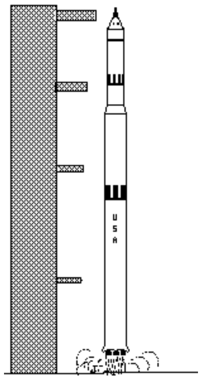


3.) (a) James Bond has a resistance of .007 x 10^8 Ω (that's 7.00 x 10^5 Ω). To escape, he hangs onto a wire carrying 1500 A of current and has a potential difference of 100,000 V from the ground. "You cannot escape, Mr. Bond," said the evil Dr. Megaohm. "That wire you are hanging on is carrying 1500 A of current, and has a potential difference of 100,000 V with the ground." "Ah, but I am not *touching* the ground," says Mr. Bond, and he works his way along the copper wire. "As you know, birds can walk along live power lines without feeling a shock." And he's right. Why? . If the copper wire between his hands has a resistance of 0.00085 Ω, how much current is going through Mr. Bond. *Hint: Is he in series or in parallel with the length of wire between his hands?*

(b) James Bond's nemesis Dr. Megaohm, as are all villains, is not as smart as Mr. Bond. So Dr. Megaohm grabs onto two wires, which have a potential difference of 100,000 V between them. Dr. Megaohm's resistance is 1.00 MΩ = 1,000,000 Ω. Find the current that goes through Dr. Megaohm.

(c) Meanwhile, there is still 1500 A going through James Bond's wire. If the copper wire between his hands has a resistance of 0.00085 Ω, how much power is being lost through Joule heating?

"*Houston, We Have A Problem…*" (50,000 points)



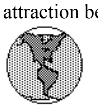
4.) The mighty Saturn V rocket, which carried Man to the Moon, stood 585 ft. tall (178 m) on the launch pad with a weight of 6.8 million pounds (30,300,000 N). The five giant F-1 engines of the S-I first stage generated a total thrust of seven and a half million pounds (33,400,000 N). (a) The exhaust of the engines goes *down*. Why does the rocket go *up*? *Short answer required.*

(b) What was the initial acceleration of the rocket?

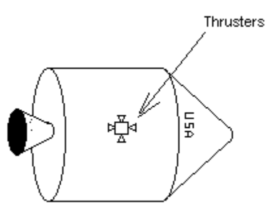
(c) Given its pale, pockmarked surface, it is probably not too silly for people a long time ago to joke (or wonder) about the Moon being made of cheese. Consider a slab of Treasure Cave™ Blue Cheese; its density is $\rho = 1183$ kg/m³ (85.2 g ÷ (2.00 cm × 6.00 cm × 6.00 cm), in case you care). Find the mass of a Bleu Cheese Moon. The Volume of a sphere is $(4/3)\,\pi\, r^3$. The radius of the Moon is 1.74×10^6 m.

"*Uh, Houston? Could You Radio Us Those Answers <u>Now</u>?*" (continued)

(d) The Earth has a mass of 5.98×10^{24} kg, while the *real* Moon (the one made of rock and not cheese) has a mass of 7.36×10^{22} kg. The distance between the Moon and the Earth is 3.82×10^8 m. Find the gravitational attraction between the Earth and the Moon. $G = 6.67 \times 10^{-11}\ N{\cdot}m^2/kg^2$.



(e) The Apollo capsule fires two thrusters: One has a force $\vec{F}_1 = 350$ N @ 45°, the other $\vec{F}_2 = 850$ N @ 135°. Find the net force, $\vec{F}$.



Atoms and Ions and Neutrons, Oh My! (50,000 points)

5.) (a) Why do all transitions from the $n = 1$ orbit in hydrogen involve photons in the UV (ultraviolet)? *Hint: In class we calculated the n = 1 to n = 2 transition and infer the rest.*

A system has 21 neutrons, 22 protons and 23 electrons. (b) What element is this?

(c) What is its *net* charge?

(d) Is this an *atom* or an *ion*? Why?

(e) Is this likely to be the *most common* isotope of this element? *Hint: See the Atomic & Nuclear handout.*

Any system with only 1 electron is called *hydrogenic* or *hydrogen-like* and we can use the Bohr model for it. Compare Hydrogen (H) and hydrogenic Uranium (U^{91+}) for:

(f) the $n = 1$ radius, r_1

(g) the $n = 1$ Energy, E_1

(h) What does the "91+" stand for?

(i) What is the Coulomb force between the $n = 1$ electron and nucleus in U^{91+}?

Consumers Power → _Consumers Energy_ Because They Sell Energy, Not Power (50,000 pts)

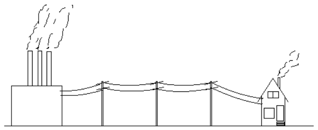
6.) We want to have 10,000 W delivered to a small neighborhood. (a) At 120 volts, what current is needed for this power?

(b) Power lines are long enough that we have to worry about their resistance. Consider a set of power lines that have R = 10 Ω. How much power is wasted if the current you found above is run through these wires? Is it more or less than the 10,000 W you actually want in the neighborhood? *Note: V ≠ 120 volts in the wires.*

(c) Real power lines use transformers to up the voltage; the power stays the same, so since P = IV, if V goes up, then I goes down. We still want to deliver 10,000 W. If the voltage is changed from 120 volts to 25,000 volts, then what is the new current?

(d) How much power is lost in the 10 Ω wires with this new current?

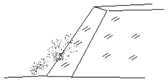
(e) Does this make a difference?



Dr. Phil's Commuting – A Full Tank of Gas Every Two Days (50,000 points)

7.) (a) One Monday Dr. Phil's 1985 Blazer stopped to get some gasoline. The odometer read `00000.9` miles… plus the previous 200,000 miles. If you figure that the average speed that one drove for all those 200,000.9 miles was 60 m.p.h., then for how many days has this Blazer been actually driving?

(b) The windshield washer fluid is pretty much water and alcohol (ρ = 900. kg/m³). The stream shoots out at a 45° angle at 4.50 m/s. What pressure does the windshield washer pump have to generate in order to get the stream to have this speed?



(c) Is this a *gauge* pressure or an *absolute* pressure in part (b)? Why?

If the windshield wasn't in the way, then (d) how high and (e) how far would the stream of windshield washer fluid travel in its parabolic arc through the air? *Still using $\vec{v}_0$ = 4.50 m/s @ 45°. Hint: The stream of fluid travels the same as if a stone had been launched at $\vec{v}_0$ = 4.50 m/s @ 45°.*