

**State Any Assumptions You Need To Make -- Circle Any Final Answers**  
**Use Your Time Wisely - Work on What You Can - Be Sure to Write Down Equations**  
**Show All Work - 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  $53^\circ$  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 its 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  $60^\circ$  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 hot dog with a mass of 0.0500 kg, what is the gravitational attraction between the hot dog and the Moon a quarter of a million miles away? ( $m_{\text{MOON}} = 7.36 \times 10^{22}$  kg ; distance =  $3.8 \times 10^8$  m)

(h) Deleted.

(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  $300^\circ\text{C}$  and  $30^\circ\text{C}$  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  $T = 20^\circ\text{C}$ .*

(n) A kid 1.00 m behind you shrieks at 100 dB. At a distance of 10.0 m, the sound is  $1/100^{\text{th}}$  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  $20^\circ\text{C}$ . How much bigger is the balloon when the temperature reaches  $30^\circ\text{C}$  in the afternoon?

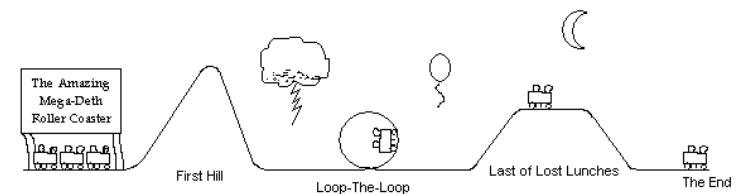
(p) At the end of the ride a friction brake is used to stop the cars, basically a piece of steel sliding on the rails. Which is important here, static or kinetic friction? Why?

(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 2<sup>nd</sup> law.*

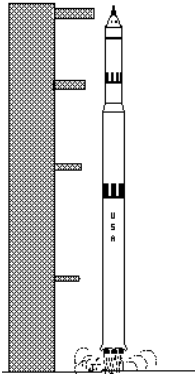
(r) If half the car's kinetic energy goes into heating a 4.00 kg block of steel, how much will the temperature of the block rise?

(s) At 5.00 m/s, what is the angular velocity of the wheels, if they are 10.0cm (0.100m) 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  $\theta = 0^\circ$  for east.*



**“Houston, We Have A Problem...” (50,000 points)**



2.) 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?

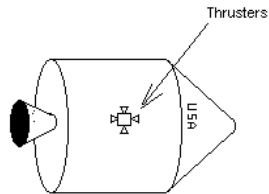
(c) Given its pale, pockmarked surface, it is probably not too silly for people a long time ago to joke (or wonder) about the Moon being made of cheese. Consider a slab of Treasure Cave™ Blue Cheese; its density is  $\rho = 1183 \text{ kg/m}^3$  (85.2 g ÷ (2.00 cm × 6.00 cm × 6.00 cm), in case you care).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

**“Uh, Houston? Could You Radio Us Those Answers Now?” (continued)**

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



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

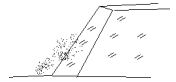


**Dr. Phil's Commuting – A Full Tank of Gas Every Two Days (50,000 points)**



3.) (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 ( $\rho = 900. \text{ kg/m}^3$ ). The stream shoots out at a  $45^\circ$  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  $v_0 = 4.50 \text{ m/s @ } 45^\circ$ . Hint: The stream of fluid travels the same as if a stone had been launched at  $v_0 = 4.50 \text{ m/s @ } 45^\circ$ .*