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: time 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: 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 < 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? (mMoon = 7.36 x 1022 kg; distance = 3.8 x 108 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°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.
“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 \( \frac{4}{3} \pi r^3 \). The radius of the Moon is 1.74 x 10^6 m.

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

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

(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 \( v_0 = 4.50 \text{ m/s @ 45}^\circ \).