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Problems set # 2 **Physics 131** September 25, 2018

1. In 2016, the U.S. imported crude oil at the rate of 7.8 Mbbl/d (7.8 million barrels/day), at a price of about \$50/bbl. *(i)* What was the annual cost to a family of 4 for imported oil? (Take the number of such families to be about 1/4 of the U.S. population, which is about 322×10^6). *(ii)* The price of gasoline at the pump, \$2.5 per gallon, is approximately given by 2.2 times the price of a gallon of domestic crude oil, plus taxes. As of 2017, taxes on gasoline amount to 18.4¢ per gallon. If taxes remain unchanged and the price for domestic crude were to rise to present import prices, what would be the price of gasoline at the pump? Do you think this price would appreciably influence American driving habits? [*Hint:* 1 bbl = 42 gal.]

2. The rocket shown in Fig. 1 has an acceleration of 30 m/s^2 until its engines burnout at 100 s. After ignition the rocket will coast and slowly lose speed: *(i)* what is its instantaneous speed at burnout? *(ii)* what is its average speed during the burnout phase ? *(iii)* what is the altitude at burnout? *(iv)* what is the altitude at the top of its trajectory. Assume the acceleration of gravity is constant, $g = 9.8$ m/s^2, up to the maximum height.

3. The unnecesary use of electric lights in the home is often cited as source of energy wastage. Suppose each person in the U.S. is responsible for the unnecessary use of a 100 watt (0.1 kW) light bulb for 1 hour each day. *(i)* What is the amount of wasted electrical energy each day? Give your answer in kWh. At 12¢/kWh, what is the added electrical cost per year to a family of 4? Does the saving of this money provide sufficient incentive to "turn off lights when not in use"? *(iii)* How many kWh electric are expended in the U.S. homes each year on unnecessary lighting? If each kWh electric demands 3 kWh of thermal heat energy, how many barrels of oil/day are burn in power plants to provide for this wasted energy? (1 bbl oil $\rightarrow 1,700$ kWh). Is it worth thinking about from a societal point of view?

4. Every few hundred years most of the planets line up on the same side of the Sun. Calculate the total force on the Earth due to Venus, Jupiter, and Saturn, assuming all four planets are in a line. The masses are $M_V = 0.815 M_\oplus$, $M_J = 318 M_\oplus$, $M_S = 95.1 M_\oplus$, and their mean distances from the Sun are $r_{\rm SV} = 108$ million km, $r_{\rm SE} = 150$ million km, $r_{\rm SJ} = 778$ million km, and $r_{\rm SS} = 1430$ million km. What fraction of the Sun's force on the Earth is this.

5. Given that the acceleration of gravity at the surface of Mars is 0.38 of what it is on Earth, and that Mars radius is 3400 km, determine the mass of Mars.

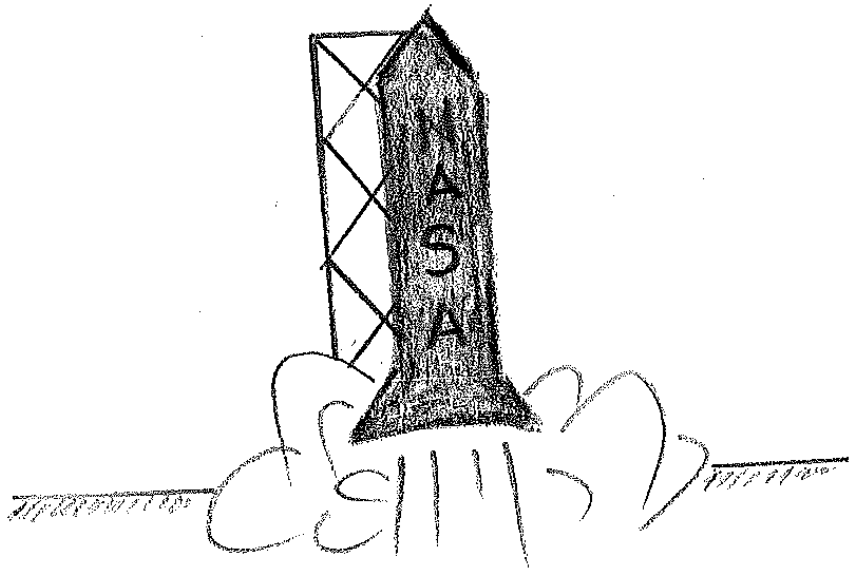

Figure 1: The situation in question 2.