Sunday study hs at Dani’s: 8 –10 pm

Homework 4 due on Monday 12/5 at 4Pm @ Mudd 168 (Dani’s office)

1. A management company offers two payment plans for leasing an apartment for one year. Plan A is designed so that a tenant’s entry cost is low, and plan B is designed so that there are more gradual price increases.

<table>
<thead>
<tr>
<th>Plan A</th>
<th>Plan B</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-month lease</td>
<td>12-month lease</td>
</tr>
<tr>
<td>$400 first month</td>
<td>$500 first month</td>
</tr>
<tr>
<td>$30 per month increase each month</td>
<td>$15 per month increase each month</td>
</tr>
</tbody>
</table>

Which plan costs more for only the 9th month of the tenancy? Which plan cost more for the whole year? Justify your answers

2. You are driving at 50 miles per hour. If you decrease the time it takes you to travel 1 mile by 8 seconds, what is your new velocity?

3. It has been proposed that dinosaurs became extinct 65 million years ago because Earth was struck by an asteroid. The idea is that dust from the impact was lofted into the upper atmosphere all around the globe, where it lingered for at least several months and blocked the sunlight reaching Earth’s surface. On the dark and cold Earth that temporarily resulted, many forms of life then became extinct. Available evidence suggests that about 20% of the asteroid’s mass ended up as dust spread uniformly over the Earth after eventually settling out of the upper atmosphere. This dust amounted to about 0.02 g/cm² of the Earth’s surface. The asteroid very likely had a density of about 2 g/cm³. Using the fact that the Earth’s total surface area is about 5.1 × 10¹⁴ m², estimate the size of the asteroid. Assuming that the shape of the asteroid was spherical, what was the diameter of the asteroid in kilometers? Note the volume of a sphere is \( V = \frac{4}{3} \pi r^3 \)

4. A Carnot engine, more commonly known as a heat engine, is a device that converts heat energy into mechanical or electrical energy. A heat engine takes advantage of the difference in temperature between two components: a hot one at a Kelvin temperature of \( T_H \) and a cold one at a Kelvin temperature of \( T_C \). Heat flows from the warmer portion to the colder one and mechanical or electrical energy is produced at a rate (in joules per second) equal to the difference between the rate of heat input in order to maintain the high temperature \( T_H \) and the rate of heat discharged in order to maintain the cooler temperature \( T_C \). The efficiency, \( \varepsilon \), of a heat engine is defined as \( \varepsilon = \frac{\text{mechanical or electrical work performed by the engine}}{\text{rate of heat energy input to the engine}} \). According to the second law of thermodynamics, the maximum efficiency, \( \varepsilon_{\text{max}} \) that a heat engine can have is

\[
\varepsilon_{\text{max}} = \frac{T_H - T_C}{T_H}.
\]

This gives the highest possible efficiency of any engine that turns heat into another form of energy. Notice that the maximum efficiency depends only on the temperatures \( T_H \) and \( T_C \) at which the engine operates.

a) Calculate the maximum efficiency of a heat engine operating between the temperatures of -129 °F and 134 °F. (These are coldest and hottest surface temperatures, respectively, ever recorded on Earth).

b) Suppose that the cold portion of a heat engine consists of ice at 32 °F. For the heat engine to have a maximum efficiency of 30% (\( \varepsilon = 0.3 \)), what should the temperature (in degrees Kelvin) of the hot portion be?

5. If the universe was such that the sun was the size of a basketball, how far away would we find Neptune from the center of Northfield’s Central Park (next to the old middle school that Carleton just bought),

a. in feet?

b. in miles?

c. in city blocks?

Potentially useful information
A city block is 500 feet (there are about 10 city blocks in a mile)
A basketball has a 1 feet diameter
The sun has a 870000 miles diameter
The distance between the sun and Neptune is \( 2795 \times 10^6 \) miles
The distance between the sun and the earth is \( 92.96 \times 10^6 \) miles