

## HW5

THIS HOMEWORK IS DUE WEDNESDAY.

ALL HOMEWORKS SHOULD BE SUBMITTED BY WEDNESDAY

Reading assignment: Einstein: 18-22.

Reading assignment: Feynman 6.1-6.3 on curved space.

For the problems below, please show all work!

1. Suppose two photons (the particle of light) are produced by the annihilation of an electron and positron (anti-electrons), both of which are at rest. (a) How much energy is carried away by the two photons? (b) Suppose you want to heat 40 gallons of water from 15.6 to 60 Celsius using electron-positron annihilation as the energy source. Heating this much water will require about 26.9 million Joules (the unit of energy) – <http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/houseenergy.html>. Provide an order-of-magnitude estimate of the cost, in US dollars, to produce the necessary amount of positrons (neglect the cost of electrons, which will be free by comparison). A good estimate for the cost of positron production is given here: [http://www.nasa.gov/exploration/home/antimatter\\_spaceship.html](http://www.nasa.gov/exploration/home/antimatter_spaceship.html).
2. A rocket is flying towards Earth at a speed  $v = .9c$ . The observer on Earth measures the rocket to be  $1000\text{km}$  above ground. (a) Draw a diagram of this situation. (b) What is the distance to Earth as measured by someone in the rocket?
3. Consequences of curved space (OPTIONAL - requires only trig). Suppose you draw a triangle on a sphere of radius  $r$  where one of the corners is located at the north pole. Derive a formula for the sum of the triangle's angles if one edge of the triangle is located on the sphere's equator. What is the area of this triangle? How could you use this information to determine if you lived in a curved space (as general relativity predicts)? BONUS: Relate the triangle's area to the sum of its angles.