PHYS 101, Fall 2002, HW #4 solutions--100 points possible.
[1.--4pts, 2.--28 pts, 3.--15 pts, 4.--15 pts, 5.--28 pts, 6.--10 pts]

1. Measure angle of sun. Must state location, date, and time. Sample answer: Nov. 19, 33.2 degrees.

2. (a) see attached graph--must be neat and carefully drawn, with points connected by a smooth curve, and the uncertainty of each data point indicated.
   (b) plot your data point, and comment on its accuracy
   (c) most rapidly spring and fall; least summer and winter. You can tell by looking at the slope of the graph--where it's steep, the angle of the sun is changing rapidly.
   (d) about 38 degrees--you must state your source
   (e) for Cville, max = 75.5 degrees, min = 28.5 degrees; these agree with the plotted data, as long as the uncertainty is taken into account.
   (f) The effective tilt = 0 about Mar 21 and Sept 23, so max angle and min angle same, and = 52 degrees. This agrees fairly well with the plotted data.
   (g) north pole latitude = 90 degrees, so formula gives max angle = 23.5 degrees and min angle = - 23.5 degrees. The negative sign means the sun is below the horizon, which is true when the north pole is tilted away from the sun. A sketch is the best way to explain this.

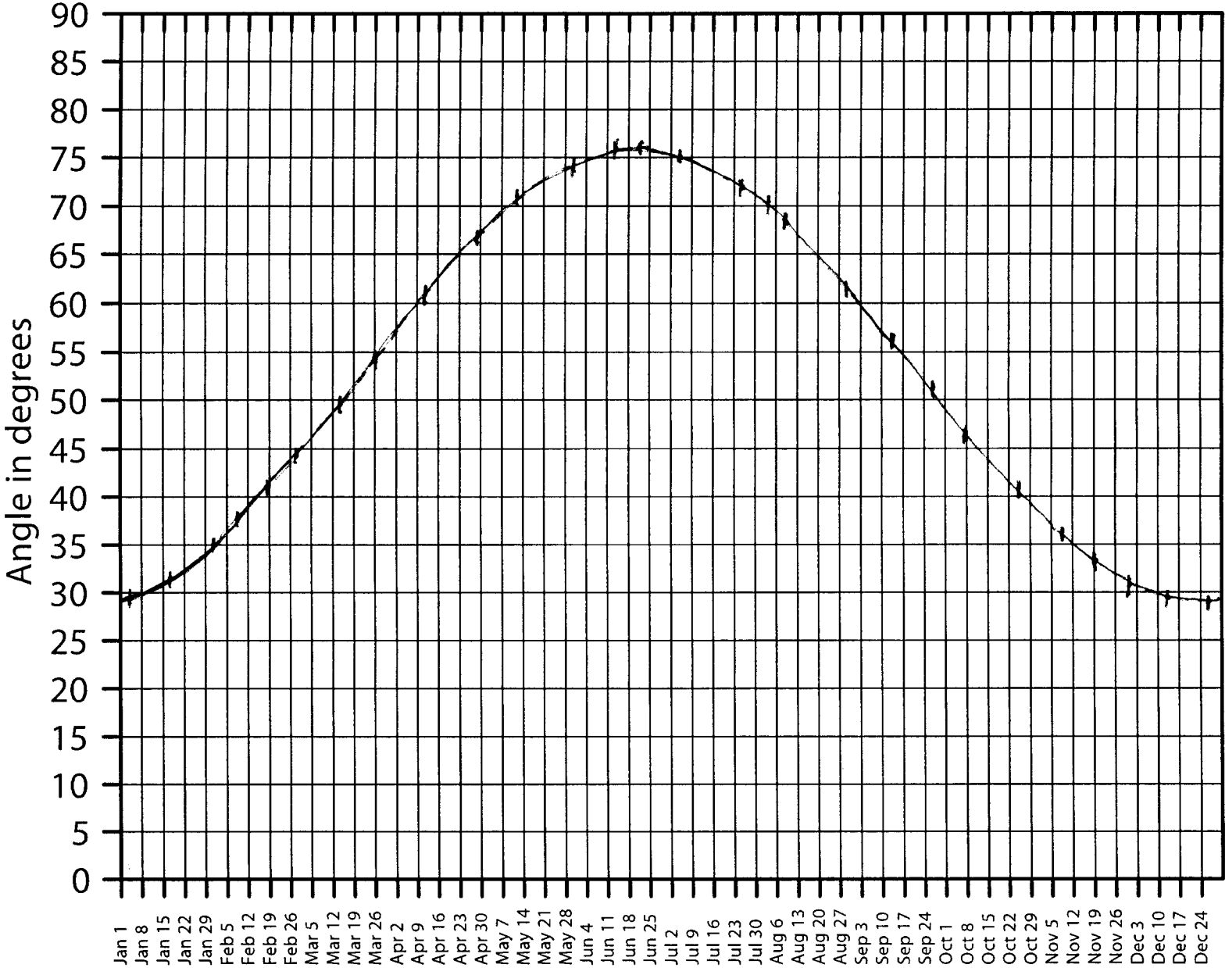
3. (a) A 15-amp circuit can, by definition, only provide 15 amps of current. The total current needed to run all these appliances (2100 watts total) is (using P=IV):

   I = (2100 watts)/(120 volts) = 17.5 amps. This is more than 15 amps, so a fuse will blow, or a circuit breaker will open the circuit. Recall from class that we actually blew a fuse intentionally. A fuse is simply a piece of wire that's designed to melt whenever the current through it exceeds a certain value. Thus the fuse "sacrifices" itself to protect the rest of the circuit.

   (b) Use P=VI and V=IR. This gives 18 ohms for the 800W oven, 144 ohms for each 100W bulb, and 14.4 ohms for the 1000W hair dryer. Notice that the higher power devices have a lower resistance--this is needed so that more is drawn.

4. (a) Redrawn, it should look like the parallel circuits from class.
   (b) Using I =P/V, we get 0.83 amps drawn by the 100-watt bulb and 0.21 amps drawn by the 25-watt radio
   (c) (125 watts)/(120 volts) = 1.04 amps, which is the sum of the two individual currents. This must be true, because the power supply can't tell a difference between a single 125-watt device, and two devices that add to 125 watts.
   (d) The currents must add exactly, just like the flow from two water pipes add to give the flow in the pipe into which they empty. This is assuming there are no water leaks, and no other sources of water.

Maximum angle of sun above horizon
Charlottesville, Virginia



5. The time intervals are related as follows:

$$\frac{\Delta t_{Earth}}{\Delta t_{Ship}} = \frac{1}{\sqrt{1-\left(\frac{v}{c}\right)^2}}$$

(a) For v/c= 0, 0.1, 0.3, 0.5, 0.9, 0.95 and 0.99, this gives time interval ratios of 1, 1.005, 1.048, 1.15, 2.29, 3.2 and 7.09 respectively.

(b) See the graph on the next page. For full credit your graph must be neat and accurate.

(c) see graph

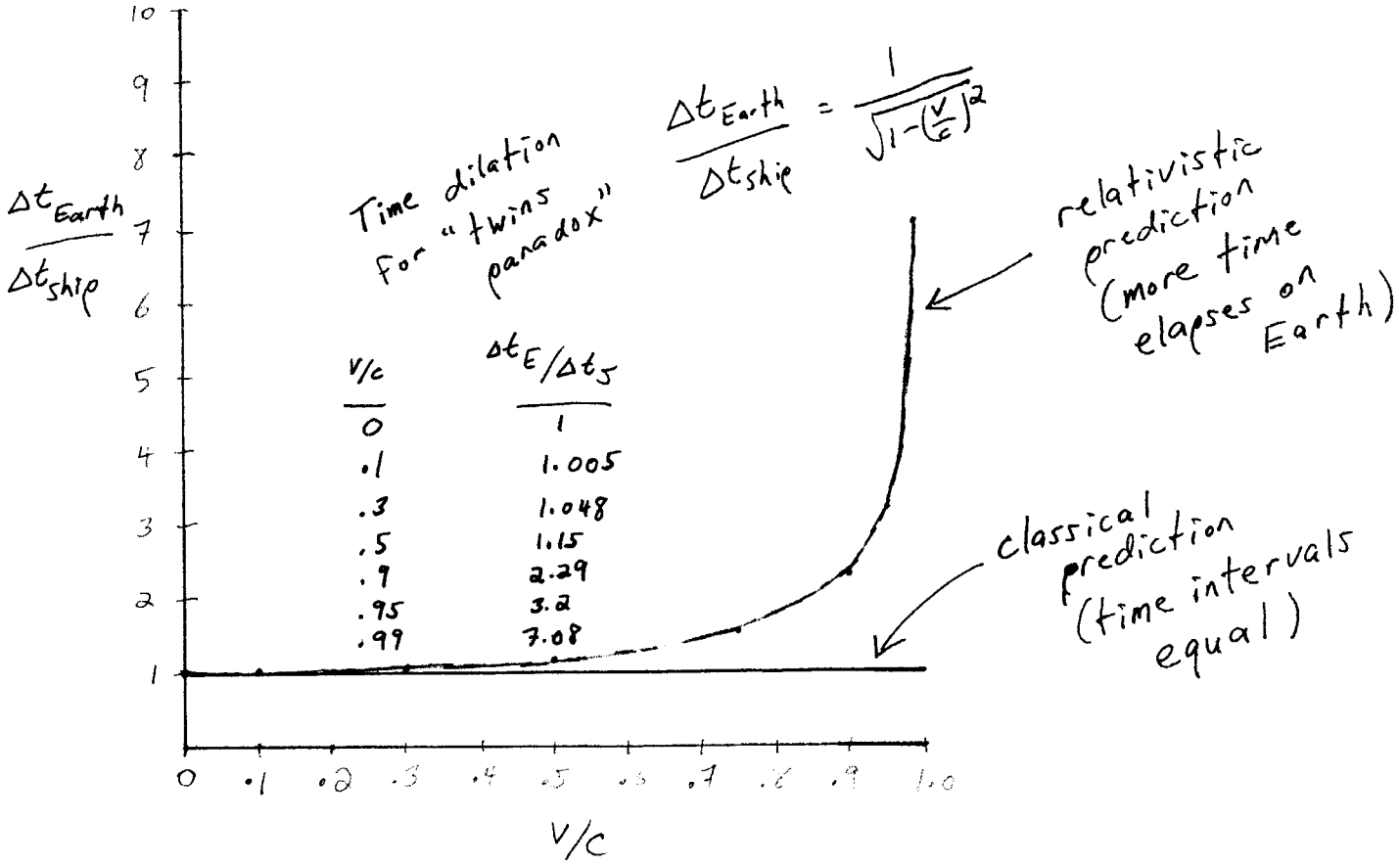
(d) I chose v/c = 0.4. Then v = 40% of the speed of light, which is 1.2×10^8 meters per second. Of course, for any speed greater than zero, there is some amount of disagreement between the theories.

(e) 40% of the speed of light translates to 268 million miles per hour.

(f) We do not notice time dilation in our everyday lives because we never travel fast enough (268 million miles per hour in my rough estimate) to cause a noticeable difference in time measurements. Even the space shuttle moves much more slowly than this (around 20 thousand miles per hour). Time dilation still exists, but the amount is very small if the relative speed of the objects involved is small compared to the speed of light.

(g) However, time dilation can and has been measured. For the case of slow-moving objects, we need an extremely accurate clock. As we discussed in class, atomic clocks are extremely accurate and were used to measure time dilation between an observer on the ground and one moving in an airplane. Fast moving objects exhibit much larger time dilation effects, and with modern particle accelerators speeds very near the speed of light are achieved--and time dilation has once again been confirmed.

6. Galilean relativity predicts that the light will be going slower or faster than c (either 1.25c or 0.75c, depending on the directions), relative to the ship. However, the actual measured result is that the light is always moving at c relative to the ship.


$\frac{\Delta t_{Earth}}{\Delta t_{ship}}$
10
9
8
7
6
5
4
3
2
1
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
V/C
Time dilation for "twins paradox"
$\frac{\Delta t_{Earth}}{\Delta t_{ship}} = \frac{1}{\sqrt{1-(\frac{v}{c})^2}}$
V/C
$\Delta t_E/\Delta t_S$
0
1
.1
1.005
.3
1.048
.5
1.15
.9
2.29
.95
3.2
.99
7.08
relativistic prediction (more time elapses on Earth)
classical prediction (time intervals equal)