PS 49: Problem 4.29

(a)

(b) Letting the program run with parameters $d = 3$, $N = 40$, and $E = 40$ for a time $> 100,000$ mcs, we obtain the mean energy of the demon $\langle E_d \rangle = 0.65$, and the mean energy per particle $\langle E \rangle / N = 0.98$. For varying N, we have the following:

Table 1: Energy values for $E = 40$.

N	$\langle E_d \rangle$	$\langle E \rangle$	$\langle E \rangle / N$
40	0.65	39.35	0.984
60	0.438	0.329	0.659
80	0.329	39.671	0.496
100	0.265	39.735	0.397

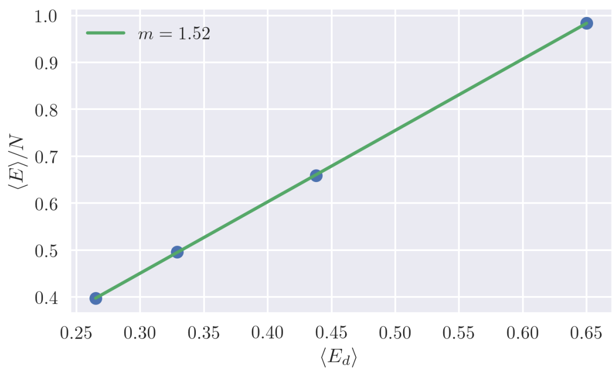

Figure 1: Relationship between $\langle E_d \rangle$ and $\langle E \rangle / N$ for $N = 40$.

From linear regression, we observe a direct relationship between $\langle E_d \rangle$ and $\langle E \rangle / N$, with a proportionality constant $m = 1.52$ or $m = \frac{31}{20} \approx \frac{3}{2}$. This implies the relation

$$\boxed{\frac{\langle E \rangle}{N} \approx \frac{3}{2} \langle E_d \rangle} \tag{1}$$

(c) The mean energy of an ideal classical gas is 3 dimensions is

$$\langle E \rangle = \frac{3}{2} NkT \tag{2}$$

Setting units of $k = 1$, and rearranging terms,

$$\frac{\langle E \rangle}{N} = \frac{3}{2} T \tag{3}$$

But (1) implies

$$\frac{3}{2} \langle E_d \rangle = \frac{3}{2} T \tag{4}$$

or

$$\boxed{\langle E_d \rangle = T} \tag{5}$$

which means that the temperature of the gas is equal to the mean energy of the demon at any N.