# Assigment 1

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1)
```
import java.util.Random;

class Rain {
	private int    n, nb;
	private double mean, variance, stddev;

	/* constructor */
	private Rain(final int n, final int nb) {
		this.n     = n;
		this.nb    = nb;
		int roof[] = new int[nb];
		/* random() double [0,1) */
		for(int i = 0; i < n; i++)
			roof[(int)(Math.random() * nb)]++;
		/* compute statistics */
		double meanSq = 0;
		for(int i = 0; i < nb; i++) {
			mean   = (roof[i]           + mean   * i) / (i + 1);
			meanSq = (roof[i] * roof[i] + meanSq * i) / (i + 1);
		}
		variance = meanSq - mean * mean;
		stddev   = Math.sqrt(variance);
	}

	/* print line */
	public String toString()
		{ return n + "\t" + nb + "\t" + mean + "\t" + stddev; }

	/* entry-point, static */
	public static void main(String args[]) {
		/* worst command-line interface ever? */
		if(args.length >= 1) { gnuplot(args[0]); return; }
		/* do the exp */
		System.out.print("#n\tnb\tmean\tstddev\n");
		System.out.print(new Rain(100,     100) + "\n");
		System.out.print(new Rain(1000,    100) + "\n");
		System.out.print(new Rain(10000,   100) + "\n");
		System.out.print(new Rain(100000,  100) + "\n");
		System.out.print(new Rain(200000,  100) + "\n");
		System.out.print(new Rain(300000,  100) + "\n");
		System.out.print(new Rain(400000,  100) + "\n");
		System.out.print(new Rain(500000,  100) + "\n");
		System.out.print(new Rain(600000,  100) + "\n");
		System.out.print(new Rain(700000,  100) + "\n");
		System.out.print(new Rain(800000,  100) + "\n");
		System.out.print(new Rain(900000,  100) + "\n");
		System.out.print(new Rain(1000000, 100) + "\n");
	}

	/* prints gnuplot data */
	private static void gnuplot(final String arg) {
		System.out.print("set terminal jpeg\n");
		System.out.print("set log xy\n");
		System.out.print("set xlabel 'N_{Av}'\n");
		System.out.print("set ylabel '\\sigma(N_{Av})'\n");
		System.out.print("plot \\\n");
		System.out.print("'" + arg + "' using 3:4 title '1 - 1000000 N, 100 NB' with points\n");
	}
}
```

gives

a)

| #n | nb | mean | stddev |
|---|---|---|---|
| 100 | 100 | 0.9999999999999996 | 0.9899494936611671 |
| 1000 | 100 | 9.999999999999998 | 3.2680269276736436 |
| 10000 | 100 | 99.99999999999999 | 10.617909398747253 |
| 100000 | 100 | 1000.0 | 29.21232616550736 |
| 200000 | 100 | 2000.0 | 45.8617487673531 |
| 300000 | 100 | 3000.0 | 49.57943121895869 |
| 400000 | 100 | 4000.0 | 70.48900623500982 |
| 500000 | 100 | 5000.000000000001 | 60.28980013229396 |
| 600000 | 100 | 6000.0 | 87.24379634103919 |
| 700000 | 100 | 6999.999999999999 | 82.22469215513038 |
| 800000 | 100 | 8000.0 | 84.69710738863218 |
| 900000 | 100 | 8999.999999999998 | 88.40769197296628 |
| 1000000 | 100 | 10000.000000000002 | 109.8537209200206 |

b)

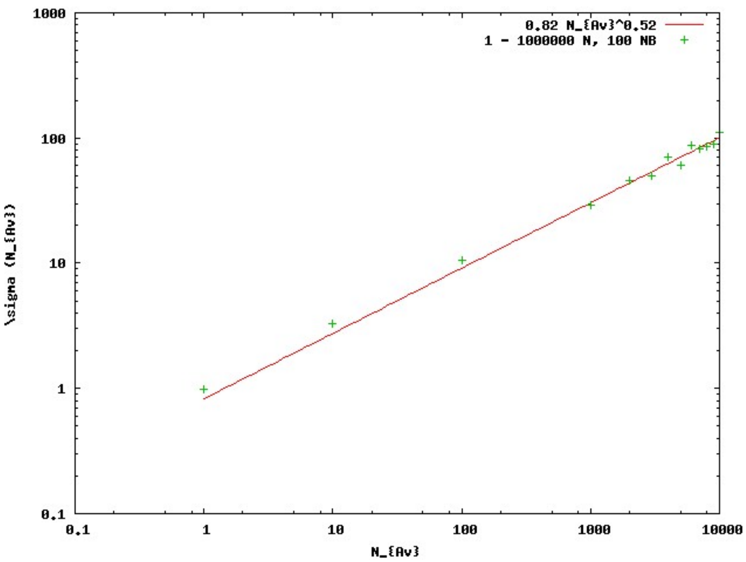



Figure 1: The rain for different values of N.

c) The fuctional relationship is $0.82{N_{Av}}^{0.52}$.

2) a) $w = f(x,z) = \frac{x^2}{z}$ and $w = f(y,z) = y^2 z$.

b) $\left(\frac{\partial\left(\frac{x^2}{z}\right)}{\partial x}\right)_y = \frac{2x}{z} = 2y$

$\left(\frac{\partial(xy)}{\partial x}\right)_z = y$

c) $\left(\frac{\partial(yz)}{\partial y}\right)_w = z = \frac{x}{y}$

$\left(\frac{\partial\sqrt{\frac{w}{x}}}{\partial w}\right)_x = \frac{1}{2\sqrt{wz}} = \frac{1}{2x}$

$(2y)(\frac{x}{y})(\frac{1}{2x}) = \frac{2x}{2x} = 1$ (close)

d) $\left(\int_0^1 xy\ dx\right)_{y=0} + \left(\int_0^1 xy\ dy\right)_{x=1} = \frac{1}{2}y^2\Big|_{y=0}^1 = \frac{1}{2}$

$\left(\int_0^1 xy\ dy\right)_{x=0} + \left(\int_0^1 xy\ dx\right)_{y=1} = \frac{1}{2}x^2\Big|_{x=0}^1 = \frac{1}{2}$

e) $\left(\int_0^1 y\, dx\right)_{y=0} + \left(\int_0^1 y\, dy\right)_{x=1} = \frac{1}{2}$

$\left(\int_0^1 y\, dy\right)_{x=0} + \left(\int_0^1 y\, dx\right)_{y=1} = \frac{1}{2} + 1 = \frac{3}{2}$

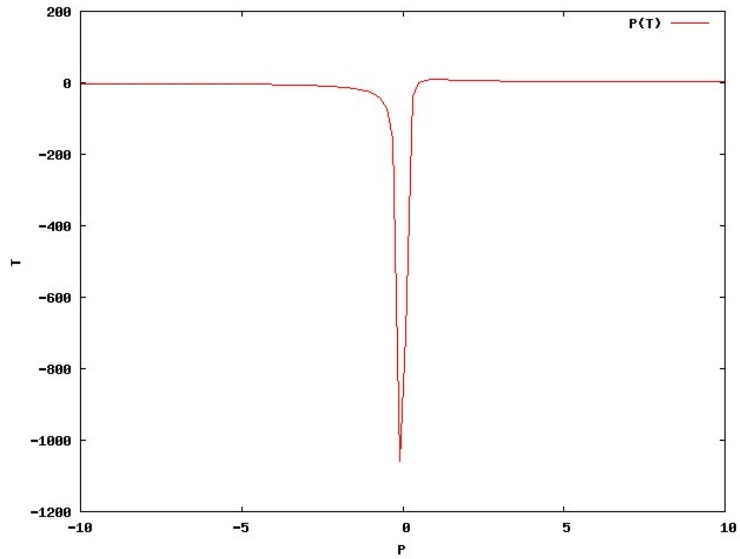
It is not conservative.

3) a)

$$\begin{aligned}
V &= \frac{\frac{8}{3}T}{P + \frac{3}{V^2}} + \frac{1}{3} \\
&= \frac{8}{3P}T + \frac{8}{9}TV^2 + \frac{1}{3} \\
\left(\frac{\partial V}{\partial T}\right)_P &= \\
&= \frac{\frac{8}{3}}{P - \frac{3}{V^2} + \frac{2}{V^3}}
\end{aligned}$$

b)

$$\begin{aligned}
\frac{V}{T} &= \frac{\frac{8}{3}}{P - \frac{3}{V^2} + \frac{2}{V^3}} \\
P - \frac{3}{V^2} + \frac{2}{V^3} &= \frac{8T}{3V} \\
P &= \frac{8T}{3V} + \frac{3}{V^2} - \frac{2}{V^3} \\
T &= \frac{3}{8}\left(P + \frac{3}{V^2}\right)\left(V - \frac{1}{3}\right) \\
P &= P - \frac{P}{3V} + \frac{3}{V^2} - \frac{1}{V^3} + \frac{3}{V^2} - \frac{2}{V^3} \\
P &= \frac{9}{V} - \frac{3}{V^2} + \frac{9}{V} - \frac{6}{V^2} \\
P &= \frac{18}{V} - \frac{9}{V^2} \\
P &= \frac{9}{V}\left(2 - \frac{1}{V}\right)
\end{aligned}$$




c)

Figure 2: The $P, T$ diagram . . . wait, that's a $P, V$ diagram.

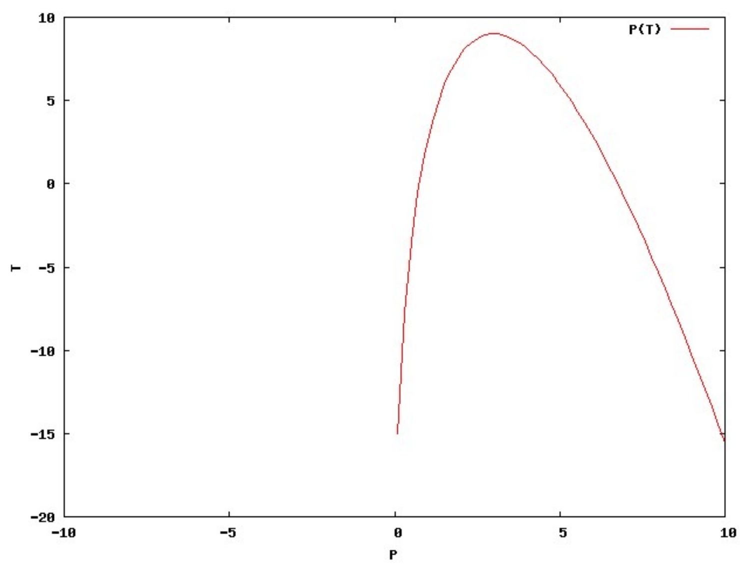



Figure 3: The $P, T$ diagram for $P = 24\sqrt{3T} - 12T - 27$. The maximum value occurs at $3$ when it is $9$. As $T$ approches $0$, the value is $-27$.