

# FoDS Prep

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## Math basics

Below are seven elementary math problems. If any of these are challenging, you should go back and review the material. From here on out we will assume these topics are common knowledge.

1. Matrix multiplication.

$$x = \begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix} \quad Y = \begin{bmatrix} 6 & 1 \\ 2 & 2 \\ 7 & 8 \end{bmatrix} \quad Y^T x = ?$$

2. Logarithms.  $\log$  will always be the natural logarithm in our class.

$$y = \log(\alpha x) \\ x = ?$$

3. Derivatives.

$$f(x, y) = ax^2 + bx + cy^3 + d \log(y) \\ \nabla_x f = ?$$

4. Finite integration.

$$g(x, y) = ax + by^2 \\ \int_{-10}^9 g(x, y) dx = ?$$

5. Expectation of a random variable.

$$\begin{aligned} p(x=1) &= 0.4 \\ p(x=2) &= 0.1 \\ p(x=3) &= 0.5 \end{aligned} \quad \mathbb{E}[x] = ?$$

6. Conditional expectation.

$$\begin{array}{ll} p(y = 0) &= 0.3 \\ p(x = 1 \mid y = 0) &= 0.4 \\ p(x = 2 \mid y = 0) &= 0.6 \end{array} \qquad \begin{array}{ll} p(y = 1) &= 0.7 \\ p(x = 1 \mid y = 1) &= 0.1 \\ p(x = 2 \mid y = 1) &= 0.9 \end{array}$$

$$\mathbb{E}[x^2 \mid y = 1] = ?$$

7. Function composition and the chain rule of derivatives.

$$\begin{array}{lll} s(x) = \log(ax) & t(s(x)) &= ? \\ t(x) = bxe^x & \nabla_x t(s(x)) &= ? \end{array}$$

## Numerical coding basics

The remainder of the refresher is available as a colab notebook: <https://colab.research.google.com/drive/1U8SiInaLjlm2GXV7p1Yccga5TLhHvacG>.

Make sure you walk through it and are comfortable with all of the ideas (lambda expressions, vectorization, sampling random variables, etc.). Homeworks in the course will require you to implement high-quality python code. If you only know another language like R, you will need to make the effort to learn python and familiarize yourself with numpy, scipy, matplotlib, and, ultimately, pytorch and pyro. We will go over pytorch and pyro with separate tutorials later in the course but familiarizing yourself with numpy, scipy, and matplotlib are up to you.