This document was created using the document configuration of

```
\documentclass[letterpaper,12pt]{article},
\usepackage[top=2cm, bottom=2cm, left=2cm, right=2cm]{geometry}
\usepackage{amsmath, amssymb}
\usepackage{fancyhdr}
\pagestyle{fancy}
```

Replicate the following problem statements and results. (You do not need to replicate the entire document)

Problem 1. In class we discussed the use of `align*` when coding a variety of mathematical equations. The following mathematics was created using `align*`[1]

$$
\begin{aligned}
(x^n)' &= nx^{n-1} & (e^x)' &= e^x & (\sin x)' &= \cos x \\
\left(\frac{1}{x^n}\right)' &= -\frac{n}{x^{n+1}} & (a^x)' &= a^x \ln a & (\cos x)' &= -\sin x \\
\left(\sqrt[n]{x}\right)' &= \frac{1}{n\sqrt[n]{x^n - 1}} & (\ln x)' &= \frac{1}{x} & (\tan x)' &= \frac{1}{\cos^2 x} \\
& & (\log_a x)' &= \frac{1}{x \ln a} & (\cot x)' &= -\frac{1}{\sin^2 x}
\end{aligned}
$$

Problem 2. Unlike `align`, which switches into math mode automatically, the `split` environment does not switch into math mode. It is intended to be applied within another math environment which provides the equation number if necessary. [2]

$$
\begin{aligned}
H_c = \frac{1}{2x} \sum_{l=0}^{n} (-1)^l (k-1)^{p-2} \sum_{l_1+\cdots+l_p=l} \prod_{i=1}^{p} \binom{n_i}{l_i} \\
\times \left[(k-l) - (k_i - l_i)\right]^{k_i - l_i} \times \left[(k-l)^2 - \sum_{j=1}^{p} (k_i - l_i)^2\right]
\end{aligned}
\tag{1}
$$

Problem 3. Another useful construct in AMS-LaTeX can be used to create piecewise definitions. Using the `cases` environment, replicate[3]

$$
P_{r-j} = \begin{cases} 0 & \text{if } r-j \text{ is odd,} \\ r!\,(-1)^{(r-j)/2} & \text{if } r-j \text{ is even.} \end{cases} \tag{2}
$$

as well as

$$
y = \begin{cases} -1 & : x < 0 \\ 0 & : x = 0 \\ +1 & : x > 0 \end{cases} \tag{3}
$$

[1] You may also need to research *left* and *right*. However, no special spacing was used.
[2] You will need to research *binom* and *prod*.
[3] *hfill* was used in the latter example.

Problem 4. Also, as discussed in class, it is quite useful to cross-reference equations that have been given in the document. As you replicate the problems above, use the LaTeXcommands `label` and `ref` to reference the split equation, (1). Also, reference the cases given in (2) and (3).