Using the document configuration of

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

Replicate the following output[1]:

Problem 1. The union of two sets $\mathcal{A}$ and $\mathcal{B}$ is the set of all elements that are in at least one[2] of the two sets and is designated as $\mathcal{A} \cup \mathcal{B}$. This operation is commutative $\mathcal{A} \cup \mathcal{B} = \mathcal{B} \cup \mathcal{A}$ and is associative $(\mathcal{A} \cup \mathcal{B}) \cup \mathcal{C} = \mathcal{A} \cup (\mathcal{B} \cup \mathcal{C})$. If $\mathcal{A} \subseteq \mathcal{B}$, then $\mathcal{A} \cup \mathcal{B} = \mathcal{B}$. It then follows that $\mathcal{A} \cup \mathcal{A} = \mathcal{A}, \mathcal{A} \cup \{\varnothing\} = \mathcal{A}$ and $\mathcal{U} \cup \mathcal{A} = \mathcal{U}$.

Problem 2. Applying l'Hôpital's rule, one has[3]

$$\lim_{x\to 0} \frac{\ln \sin \pi x}{\ln \sin x} = \lim_{x\to 0} \frac{\pi \frac{\cos \pi x}{\sin \pi x}}{\frac{\cos x}{\sin x}} = \lim_{x\to 0} \frac{\pi \tan x}{\tan \pi x} = \lim_{x\to 0} \frac{\pi / \cos^2 x}{\pi / \cos^2 \pi x} = \lim_{x\to 0} \frac{\cos^2 \pi x}{\cos^2 x} = 1$$

Problem 3. The gamma function Γx is defined as

$$\Gamma(x) \equiv \lim_{n\to\infty} \prod_{v=0}^{n-1} \frac{n! n^{x-1}}{x+v} = \lim_{n\to\infty} \frac{n! n^{x-1}}{x(x+1)(x+2)\cdots(x+n-1)} \equiv \int_0^\infty e^{-t} t^{x-1}\, dt$$

Problem 4. The total number of permutations of n elements taken m at a time (symbol P_n^m) is[4]

$$P_n^m = \prod_{i=0}^{m-1} (n-1) = \underbrace{n(n-1)(n-2)\ldots(n-m+1)}_{\text{total of } m \text{ factors}} = \frac{n!}{(n-m)!}$$

Problem 5. After researching headers in LaTeX, develop your own header to be used with this assignment and all future assignments. The header should contain your name, the assignment reference and, optionally, the date of submission[5].

[1] research *footnote*, *description* and *vspace*(I used a 5mm vertical spacing between items) in LaTeX
[2] research *cup*, *cap* and other set operators in LaTeX.
[3] research accents, *lim* and *frac* in LaTeX
[4] research *overbrace* and *underbrace* in LaTeX
[5] Also research *fancyhdr* and *today*