You may use \texttt{enumerate} to generate answers for each question:

6.1. Type of commonly used notations. Use another \texttt{enumerate} to start generate answers for sub-questions:

(a) Use $\newcommand*{\Prob}{\mathbb{P}} \Prob(A) \equiv \mathbb{E}[\mathbb{E}(A)]$.

(b) Use \texttt{equation} to have equation in display math mode:

\[
\frac{a + b}{2} \geq \sqrt{ab} \tag{1}
\]

(c) Use \texttt{eqref} to get reference for equations: \eqref{1} holds when $a \geq 0, b \geq 0$.

(d) Now we would introduce some commonly used notations:

i. Use $\newcommand*{\reals}{\mathbb{R}} \reals, \mathbb{E}, \Var(y), \Prob(A), \independent, \perp \perp$ by typing \texttt{\reals, \E\[\rvx\], \Var(\rvy), \Prob(A), \independent, \1}.

ii. Now you can use $\newcommand*{\ux}{\underline{x}}, \newcommand*{\uy}{\underline{y}}, \newcommand*{\uz}{\underline{z}}$ to type vectors $x, y, z$.
α) Writing $P(x)$ is wrong. $P$ should only operate on events.

β) $x$ is a random variable, while $x$ is a real number.

(c) You may find [https://en.wikibooks.org/wiki/LaTeX](https://en.wikibooks.org/wiki/LaTeX) useful.

(f) Writing L\TeX online may be easier for beginners:

i. ShareLaTeX: [https://www.sharelatex.com/](https://www.sharelatex.com/).

ii. Overleaf: [https://www.overleaf.com/](https://www.overleaf.com/).

6.2. You may need aligned equations for your homework, here are several examples:

Total probability rule:

$$P(x = x) = \sum_{y \in Y} P(x = x, y = y)$$

$$= \sum_{y \in Y} P(x = x | y = y) P(y = y),$$

or

$$P_x(x) = \sum_{y \in Y} P_{xy}(x, y)$$

$$= \sum_{y \in Y} P_{x|y}(x | y) P_y(y).$$

Indicator function:

$$\mathbb{1}_A(\omega) = \begin{cases} 1, & \text{if } \omega \in A, \\ 0, & \text{if } \omega \notin A. \end{cases}$$

6.3. You may need to add figure and source codes in your homework. Figure ?? is an example that compares the empirical distribution (histogram) and probability density function of the Gaussian random variable.

The source code to plot Figure ?? could be found in Appendix ??.

Here are the core codes:

```latex
4 [cnt, x_hist] = hist(data, nbins); % not to plot, only to get empirical distribution.
6 cnt = cnt / n / (x_hist(2) − x_hist(1)); % normalization, be careful :)
7 bar(x_hist, cnt); % plot the hist using bar()
```

To understand line 6, note that if we have $n$ samples of $x$ denoted by $x^{(i)}$, $i = 1, 2, \cdots, n$, then the probability density function $p_x$ could be estimated as

$$p_x(x_0) = \left. \frac{d}{dx} P(x \leq x) \right|_{x=x_0}$$

$$\approx \frac{P(x_0 - \Delta x < x \leq x_0)}{\Delta x}$$

$$\approx \frac{1}{n\Delta x} \sum_{i=1}^{n} \mathbb{1}_{x^{(i)} \in [x_0 - \Delta x, x_0]} .$$
6.4. An example of hypothesis testing:

$$\log \frac{\mathbb{P}(H = H_1 | y = y)_{H=H_1}}{\mathbb{P}(H = H_0 | y = y)_{H=H_0}} < \gamma$$
A Source code

Source code for plotting Figure ?? is shown as follows.

```matlab
n = 1e6; % n samples
data = randn(1e6, 1); % Generate n Random Gaussian samples.
nbins = 50; % bins in your histogram
[cnt, x_hist] = hist(data, nbins); % not to plot, only to get emperical distribution.
figure;
cnt = cnt / n / (x_hist(2) - x_hist(1)); % normalization, be careful :)
bar(x_hist, cnt); % plot the hist using bar()
hold on;
x = -5 : 0.1 : 5;
plot(x, normpdf(x), 'r', 'linewidth', 2);
legend({'\hat{p}_{\sf{x}}(x)$', '$p_{\sf{x}}(x)$'}, 'Interpreter', 'LaTeX', 'fontsize', 15);
xlabel('$x$', 'Interpreter', 'LaTeX', 'fontsize', 15); % You may change the size accordingly
ylabel('$p_{\sf{x}}(x)$', 'Interpreter', 'LaTeX', 'fontsize', 15);
title{'(your-title-here)'}
```

Listing 1: FigurePlot