Exam #1 (75 points)

- **Show your work for partial credit.** It is very difficult to give partial credit if the only thing on your page is \(x = 3\).

- If possible, take the exam during an **uninterrupted period of no more than 4 hours.** (It should not take that long.) In any case, do not spend more than 4 hours on the exam.

- **Other than this cheat sheet, all you are allowed to use for help are the basic functions on a calculator.** Partial translation: no books, no notes, no websites, no talking to other people, and no advanced calculator features like programmable functions or present value formulas.

- People who have taken the exam can talk to each other all they want, and people who have not taken the exam can talk to each other all they want, but communication between the two groups about class should be limited to three phrases: “Yes”, “No”, and “Have you taken the exam?”

- **Expected value** is given by summing likelihood times value over all possible outcomes:

\[
\text{Expected Value} = \sum_{\text{Outcomes } i} \text{Probability}(i) \cdot \text{Value}(i).
\]

- **A fair bet** is a bet with an expected value of zero.

- The **future value of a lump sum payment** of \(x\) invested for \(n\) years at interest rate \(s\) is \(FV = x(1 + s)^n\). The **present value of a lump sum payment** of \(x\) after \(n\) years at interest rate \(s\) is \(PV = \frac{x}{(1 + s)^n}\). (Note that this formula also works for values of \(n\) that are negative or zero.)

- The present value of an **annuity** paying \(x\) at the end of each year for \(n\) year at interest rate \(s\) is

\[
PV = x \left[ \frac{1 - \frac{1}{(1 + s)^n}}{s} \right].
\]

The present value of the related **perpetuity** (with annual payments forever) is

\[
PV = \frac{x}{s}.
\]

- The **inflation rate**, \(i\), is the rate at which prices rise. The **nominal interest rate**, \(n\), is the interest rate in terms of dollars. The **real interest rate**, \(r\), is the interest rate in terms of purchasing power. These are related by

\[
1 + r = \frac{1 + n}{1 + i}.
\]

When the inflation rate is small, we can approximate this as

\[
r \approx n - i.
\]
1. A pharmaceutical company comes out with a new pill that prevents baldness. When asked why the drug costs so much, the company spokesman replies that the company needs to recoup the $1 billion it spent on research and development (R&D).

(a) (5 points) Will a profit-maximizing firm pay attention to R&D costs when determining its pricing? Yes  No (Circle one and explain briefly.)

(b) (5 points)

- **If you said “Yes” above:** Do you think the company would have charged less for the drug if it had discovered it after spending only $5 million instead of $1 billion? Yes  No (Circle one and explain briefly.)

- **If you said “No” above:** Do R&D costs affect the company’s behavior before they decide whether or not to invest in the R&D, after they invest in the R&D, both before and after, or neither?

2. (6 points) If the nominal interest rate is 10% and the rate of inflation is 4%, calculate the real interest rate, using both the rule of thumb and the actual formula.
3. Geothermal energy involves “mining” heat by drilling into the earth’s crust. Like many clean energy technologies, it has high up-front costs but promises to pay off over time. The made-up numbers in this problem look at the economics of geothermal power. (For the real numbers, see the 2007 MIT report “The Future of Geothermal Energy”.)

(a) (5 points) Consider spending $1000 today to build a geothermal plant that will generate $100 at the end of each year for the next 30 years. Show that the present value of the costs outweigh the present value of the benefits if the interest rate is 13%.

(b) (5 points) In order to make geothermal more attractive, does the interest rate need to go up or down? Briefly explain.

(c) (5 points) What will the present value of benefits be if the plant generates $100 a year forever instead of just for 30 years? (The interest rate is still 13%).

(d) (5 points) Explain (as if to a non-economist) why the present value of benefits will not be infinite even though the plant will operate forever.
4. “Opportunities for arbitrage are self-eliminating.”

(a) (5 points) Explain this statement in the context of lanes of traffic on a congested freeway.

(b) (5 points) Many economists believe that a similar logic holds when it comes to making investments for, say, a retirement fund. Describe their investment advice, or otherwise explain.

5. Choosing a president is undoubtedly a more important decision than (say) choosing what kind of car you’re going to buy. But many people spend hours deciding what kind of car to buy and only minutes deciding which presidential candidate to vote for. This problem tries to explain why.

(a) (5 points) Calculate the expected value of each of the following activities. Activity #1 pays $1 million with probability 0.0001 and $0 with probability 0.9999. Activity #2 pays $1000 with probability 1.

(b) (5 points) Use the analysis above to explain why many people spend hours deciding what kind of car to buy and only minutes deciding which presidential candidate to vote for.
6. Imagine that you are a profit-maximizing forester. You currently own trees containing 100 board-feet of timber.

(a) (5 points) With probability 2%, a fire will destroy your trees, and you'll have no harvestable timber. With probability 98%, your trees will grow and in one year you'll have 5% more board-feet of timber. What is the expected number of board-feet of timber you'll have next year?

(b) (5 points) Explain (as if to a non-economist) why the interest rate at the bank matters in deciding to cut the trees down now or to cut them down in year.

(c) (6 points) Assume that the price of lumber grows at the rate of inflation and that you're a risk-neutral forester. In order for cutting the trees down next year to be a better choice than cutting the trees down now, the (circle one: nominal real) interest rate has to be (circle one: higher lower) than ____________.