Questions are to be done independently by each student, but it’s ok to confer about theoretical principles (as opposed to showing or suggesting specific answer details to one another).

**Problem 1 (Human knowledge and reasoning, and future)**

A. For this question, refer to the Steven Pinker excerpt (from *How the Mind Works*, Norton, 1997: 186-190) at the link from the instructor’s web page for 244/444. (http://www.cs.rochester.edu/~schubert/444/notes/pinker)

What aspects of Pinker’s commentary on human cognition do you regard as particularly relevant to the theme of CSC 244/444, i.e., knowledge representation and reasoning (including planning) in intelligent systems? Why/how? (Answer in about 200 words.)

B. Another of the articles linked to from the instructor’s web page is a brief opinion piece by Kai-Fu Lee (who has written more fully on this in a book “AI Super Powers”). Lee argues that there will be a further concentration of wealth in the hands of a few — and on a national scale, in the US and China — as a result of ever-broader deployment of AI technology.¹

A seemingly inexorable trend running in parallel with the rise of AI is the over-exploitation of the globe by an ever-growing, ever more resource-hungry world population, with consequent increasing global warming, melting ice caps, rising seas, pollution of land and water, deforestation, devastating droughts and storms, and wars, epidemics, and mass refugee crises as people try to survive and gain access to the opportunities and wealth of their countries’ elites and of the more developed nations. Some analyses predict catastrophic societal and economic chaos, wars and collapse within about 25-40 years if current trends continue.

Write a brief essay (perhaps 1 - 1.5 pages), making reference to readings supplied in this course (again, see the articles linked to from the course web page) and perhaps others you might find, about what your generation can do to avert catastrophe, with particular reference to the role of AI in our future. (Of course this is bound to be speculative, but don’t simply write “off the top of your head”, rather, try to ground what you say in reputable sources.)

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¹In a rather disquieting way, Vladimir Putin has made such a point; he told students in an open lesson about science, “Artificial intelligence is the future, not only for Russia, but for all humankind. It comes with colossal opportunities, but also threats that are difficult to predict. Whoever becomes the leader in this sphere will become the ruler of the world.”
Problem 2 (Logical Syntax)

Which of the following expressions can be well-formed formulas, and which cannot, according to the FOL syntax discussed in class (and notes)? Briefly explain what the problem is, or why there is no problem, for each (putative) formula. Remember that we use capitalization for predicates, capitalization for individual constants (the B&L text also allows lower-case individual constants, but we won’t), and lower case for variables and functions.

Omission of brackets is considered an error if and only if it creates an ambiguity. Don’t assume any precedence ordering among $\lor$, $\land$, and $\Rightarrow$, but you can assume that $\neg$ applies to the smallest (well-formed, bracket-balanced) formula that it precedes. Note that certain complex formulas, like $B = f(A) \lor P(C)$, are unambiguous despite some omitted brackets — here we know it must be $((B = f(A)) \lor P(C))$, because $(f(A) \lor P(C))$ would be ill-formed, combining a term with a formula.

For quantified sentences, assume that for delimiting the scope of a quantifier we allow both bracketing (e.g., wffs of form $(\forall x \phi)$) and the “dot” notation (e.g., sentences of form $\forall x. \phi$, where the scope of the quantifier is understood to reach as far to the right as possible without including an unbalanced right bracket). Note that the syntax we’re using allows formulas with unbound variables (i.e., “open” formulas), and it allows the same variable to be used with multiple quantifiers.

A. $\forall x. \text{Believe}(\text{Mary},x) \Rightarrow \text{Believe}(\text{John},x)$
B. $\text{Smart}(\text{Mary}) \land \text{Believe}(\text{John}, \text{Smart}(\text{Mary}))$
C. $\forall x. \text{Loves}(x,(\forall y \text{ Child-of}(x,y)))$
D. $P(A) \Rightarrow \text{True}(P(A))$
E. $\text{True}(p(A)) \lor \text{True}(\neg \text{negation}(p(A)))$
F. $P(A) \Rightarrow \exists x P(A,x)$
G. $\forall x. \exists y. P(x,y,z)$
H. $\forall x. \exists x. P(x)$

Problem 3 (from English to Logic)

A. Express the following propositions in FOL. For “plot (of)” use a function plot-of; some suggested predicates are indicated as well:

   a. The plot of Blade Runner is based on a story by Philip K. Dick. (Based-on, Story-by)
   b. The plot of every science fiction movie is speculative. (Sci-fi-movie)
   c. The plot of some science fiction movie is speculative.
   d. The only interesting AI movie released in 2015 was Ex Machina.
      (Interesting, AI-movie, Released-in)
      Note: This really has two aspects — that Ex Machina is an interesting AI movie released
      in 2015, and that any other AI movies released in 2015 are not interesting (or, every
      interesting AI movie released in 2015 is the same as Ex Machina!)
   e. Of all birds, only parrots and Mynah birds can talk.
      (Again, there are 2 aspects here. Also, assume that “Parrots can talk” means that at
      least some parrots can talk, and similarly for mynah birds.)
f. Every student met a friend today.  (Assume a predicate \textit{Meet} whose last argument is the time of meeting; also assume a particular day, such as Sept-21-2018, for “today”)

g. I shall give all those of you who prove or disprove Goldbach’s conjecture a bonus point. 
\textit{(Give, Prove, Disprove} (each with a time argument), \textit{Bonus-point}).

Treat “Goldbach’s conjecture” as a constant, and make up three constants for a particular speaker, speech time and audience (the latter will denote a set of individuals). Note that in talking about some future time of proving or disproving Goldbach’s conjecture, or giving a bonus point, you shouldn’t use a time \textit{constant}, but rather use an existentially quantified time, appropriately constrained in relation to certain other times.

h. No politician can fool all of the people all of the time.

B. Briefly comment on the nature of the difficulties (if any) you encounter in trying to encode the following kinds of assertions in FOL. You might characterize the difficulties purely in words, or you might write down an FOL approximation and explain its shortcomings, or you might use some \textit{ad hoc} representation that uses constructs not available in FOL, and comment on that (comments on both the syntax and \textit{semantics} of attempted representations are pertinent). Do not resort to “solution by concatenation”, e.g., using “Jog-frequently” for ”jogs frequently”, or “Fake-diamonds” for “fake diamonds” (however, adding trailing prepositions, e.g., “Evolve-from” in (e), is ok):

a. Most dogs are friendly.  (cf., \textit{All dogs} …)

b. Mary jogs frequently. (cf., \textit{Mary jogged during the lunch break today}.)

c. John believes there are ghosts.

d. Fake diamonds are not diamonds.  (cf., \textit{High-quality diamonds} …)

e. Humans evolved from apes.