Homework 3
Due Sunday 10^{th} Dec.
Total points: 10

1. Give a CCG derivation for the following sentence: 2 points

   The company added four Boeing-747s to the two units in 1994

   Indicate clearly which CCG combinator is being used at each step, and assume the following lexical categories:

   added : $((S \setminus NP)/PP)/NP$
   to : PP/NP
   in : $((S \setminus NP) \setminus (S \setminus NP))/NP$
   The, four : NP/N
   two : N/N
   1994: NP
   Boeing-747s, company, units : N

   Hint: CCG assigns different lexical categories to prepositional phrases that are 'arguments' of verbs and those that are 'adjuncts'. In the above sentence, the prepositional phrase 'to the two units' is an argument of *add*. The other prepositional phrase 'in 1994' is an adjunct.

2. Suppose we are using a MaxEnt model for disambiguating three senses of the word *plant*, where y represents the latent sense.

y =	sense
1	Noun: a member of the plant kingdom
2	Verb: to place in the ground
3	Noun: a factory

   (a) We saw the equation for $P(y|\vec{x})$ in a MaxEnt model. Write down a simplified expression for the log probability, $logP(y|\vec{x})$. Can you say why MaxEnt models are also called log-linear models? 1 points

   (b) Imagine we have already trained the model. The following table lists the features $\vec{x}$ we are using, and their weights $\vec{w}$ from training: 2 points

feat. #	feature	weight
1	`doc_contains('grow')` & y=1	2.0
2	`doc_contains('grow')` & y=2	1.8
3	`doc_contains('grow')` & y=3	0.3
4	`doc_contains('animal')` & y=1	2.0
5	`doc_contains('animal')` & y=2	0.5
6	`doc_contains('animal')` & y=3	-3.0
7	`doc_contains('industry')` & y=1	-0.1
8	`doc_contains('industry')` & y=2	1.1
9	`doc_contains('industry')` & y=3	2.7

where `doc_contains('grow')` means the document containing the target instance of *plant* also contains the word *grow*. Now we see a new document that contains the words industry, grow, and plant. Compute $\sum_i w_i f_i(\vec{x}, y)$ and $P(y|\vec{x})$ for each sense y. Which sense is the most probable?

3. Convert the following FOL expressions into natural language sentences. 2 points

   (a) $\forall x.bear(x) \Rightarrow furry(x)$

   (b) $\exists e.x.y.eating(e) \wedge pizza(x) \wedge fork(y) \wedge eater(e, Sergii) \wedge eaten(e, x) \wedge instrument(e, y)$

   (c) $\forall x.student(x) \Rightarrow \exists e.lifting(e) \wedge lifter(e, x) \wedge liftee(e, Marie)$

   (d) $\exists e.lifting(e) \wedge \forall x.student(x) \Rightarrow lifter(e, x) \wedge liftee(e, Marie)$

4. Convert the following natural language sentences into FOL expressions. Use reified event semantics. If a sentence is ambiguous, list all possible interpretations and give paraphrases of the different meanings. 1 points

   (a) Juan hates pasta.

   (b) Some student likes every class.

5. Assume the following grammar with semantic attachments 2 points

$S \rightarrow NP\ VP$	$VP.sem(NP.sem)$
$VP \rightarrow V_t\ NP$	$V_t.sem(NP.sem)$
$VP \rightarrow V_i$	$V_i.sem$
$NP \rightarrow N$	$N.sem$
$N \rightarrow Sam$	Sam
$N \rightarrow Whiskers$	Whiskers
$V_t \rightarrow likes$	$\lambda x.\lambda y.\exists e.Liking(e) \wedge Liker(e, y) \wedge Likee(e, x)$
$V_i \rightarrow meows$	$\lambda x.\exists e.Meowing(e) \wedge Meower(e, x)$

Show how the meaning of the sentence *Whiskers likes Sam* is built up using this grammar.