CS/ECE 348
Summer 2001
Homework 6: Bayesian Networks

Handed out: Friday, July 20th
Due: In class, Thursday, July 26th

For this homework, you will be working with Bayesian Networks, with pencil and paper, and also using a Java applet. You'll practice inference on a network, enter the network into the applet to confirm your answer, then design a simple network and perform some queries on it.

You need to submit, on paper, your answers to the questions below. There will be no programming for this assignment.

As always, start early, ask lots of questions, discuss general issues (but not solutions) with your friends, and state any assumptions you need to make.

1. **(40 points) Inference by Enumeration**

   (40 points) As noted in class, you can combine utility theory with probability theory in Bayesian networks. The graph on the last page gives an example of such a combined network. The *Test* and *Drill* nodes do not have CPTs, since they must be assigned values in order for an inference to be performed. (In other words, their priors are undefined.) The *Profit* node is a utility node, and must be the queried node. Its CPT contains not probabilities, but utilities that depend on its parents. (You could rewrite the CPT using probabilities of 0 and 1, as in the *Result* node, but the table would be somewhat large.)

   Using the *inference by enumeration* procedure described in class, calculate the value of *Profit* for the following queries. Show enough work that we can see that you did the work yourself.

   (a) `Profit | Test=Y, Drill=Y, Result=Open`

   (b) `Profit | Test=N, Drill=Y`

   Things you may need to think about (but need not include in your writeup): How do I write an expression for this query that can be solved by the enumeration procedure? Do I need to worry about normalization, and if so, how? How do I adjust the procedure to deal with utilities instead of probabilities?

2. **(20 points) Using a Bayesian Network applet**

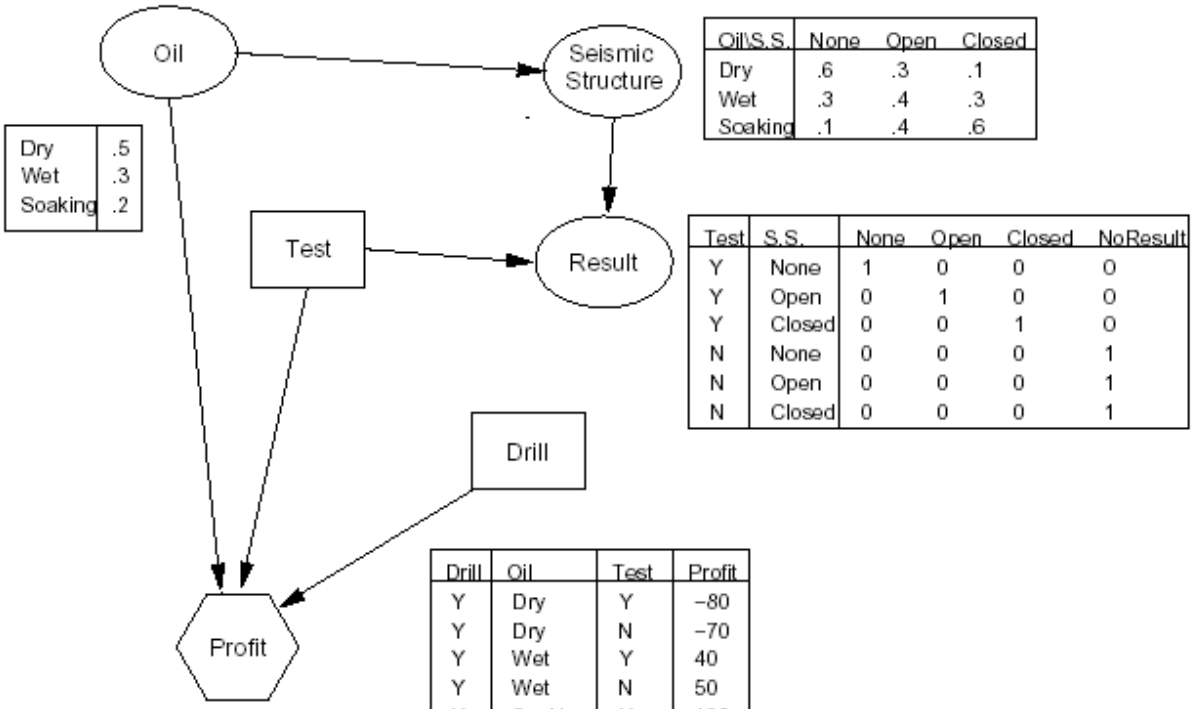
   (20 points) Enter the network into a Bayesian Network system, and confirm that your answers in Question 1 were correct. (Note that you can expect a problem like Question 1 on the exam, and you won't have a computer to help you then, so make sure you know how to do inference by enumeration!) You'll need to invent priors for the *Test* and *Drill* variables, and you'll need to convert the CPT for *Profit* into a form that the system can use.

   Here's a good Bayesian Network applet:
   `http://www.cs.ubc.ca/labs/lci/CIspace/bayes.html`

   Answer the following questions briefly:

   For your network, what is the probability distribution of *Oil* given only that $Profit = 50$? How and why does this result depend on the priors for *Test* and *Drill*?

   ; The priors for Test and Drill don't affect the value of Oil.
   ; Oil and either of those nodes are independent, given the value of Profit.



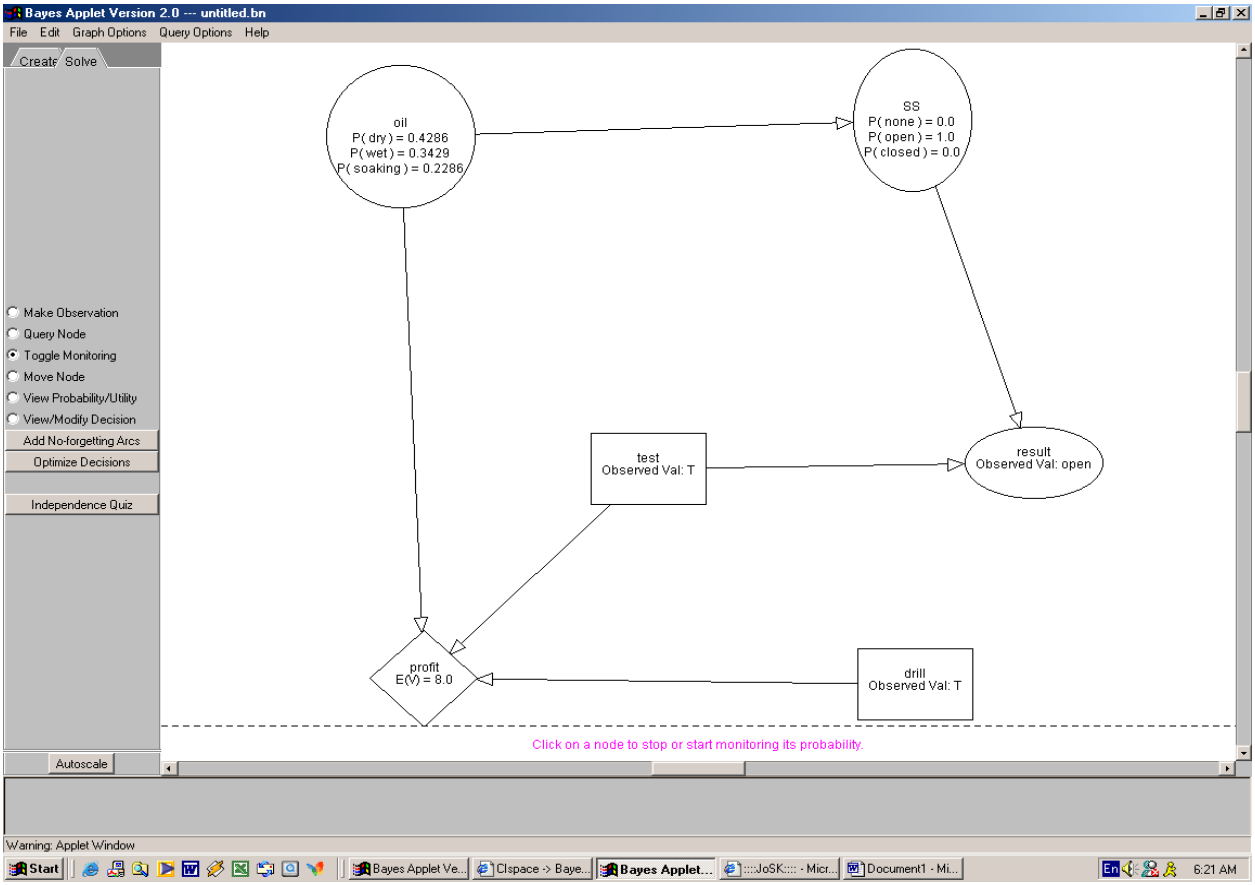
Dry	.5
Wet	.3
Soaking	.2

Oil\S.S.	None	Open	Closed
Dry	.6	.3	.1
Wet	.3	.4	.3
Soaking	.1	.4	.6

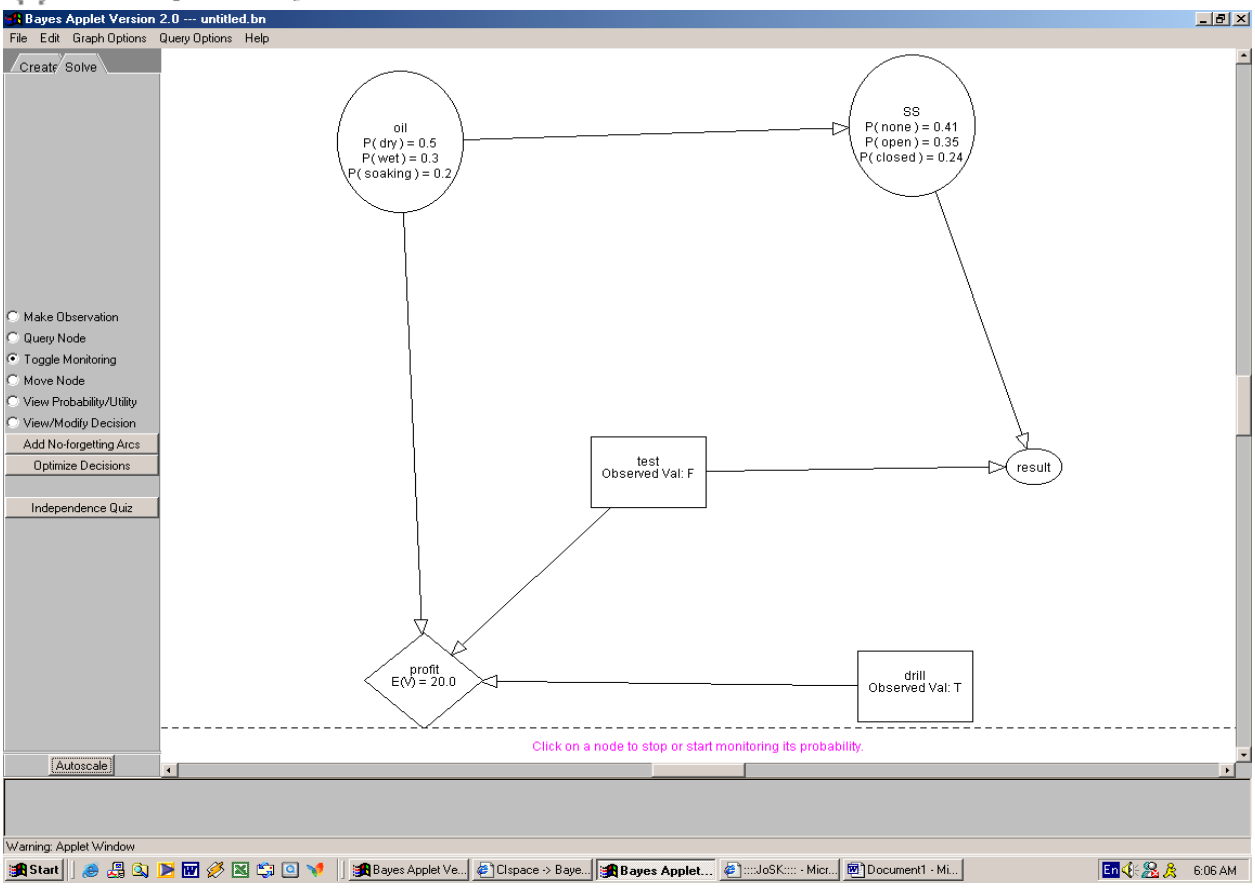
Test	S.S.	None	Open	Closed	NoResult
Y	None	1	0	0	0
Y	Open	0	1	0	0
Y	Closed	0	0	1	0
N	None	0	0	0	1
N	Open	0	0	0	1
N	Closed	0	0	0	1

Drill	Oil	Test	Profit
Y	Dry	Y	−80
Y	Dry	N	−70
Y	Wet	Y	40
Y	Wet	N	50
Y	Soaking	Y	190
Y	Soaking	N	200
N	Dry	Y	−10
N	Dry	N	0
N	Wet	Y	−10
N	Wet	N	0
N	Soaking	Y	−10
N	Soaking	N	0

(a) Profit | Test=Y, Drill=Y, Result=Open



(b) Profit | Test=N, Drill=Y



3. **(40 points) Network Construction**

(40 points) Create a new network in the applet using the variables described below. Draw reasonable edges representing causality, and fill in the CPTs with reasonable numbers (for, say, a typical college student – no 0s or 1s, please!).

- **Eyes –** (Normal, Bloodshot, Glazed)
- **Grades –** (Good, Poor)
- **Sleep –** (Normal, Excessive, Not Enough)
- **Using Drugs –** (Yes, No)
- **Have Money –** (Yes, No)
- **Own Textbooks –** (Yes, No)
- **Working –** (Yes, No)

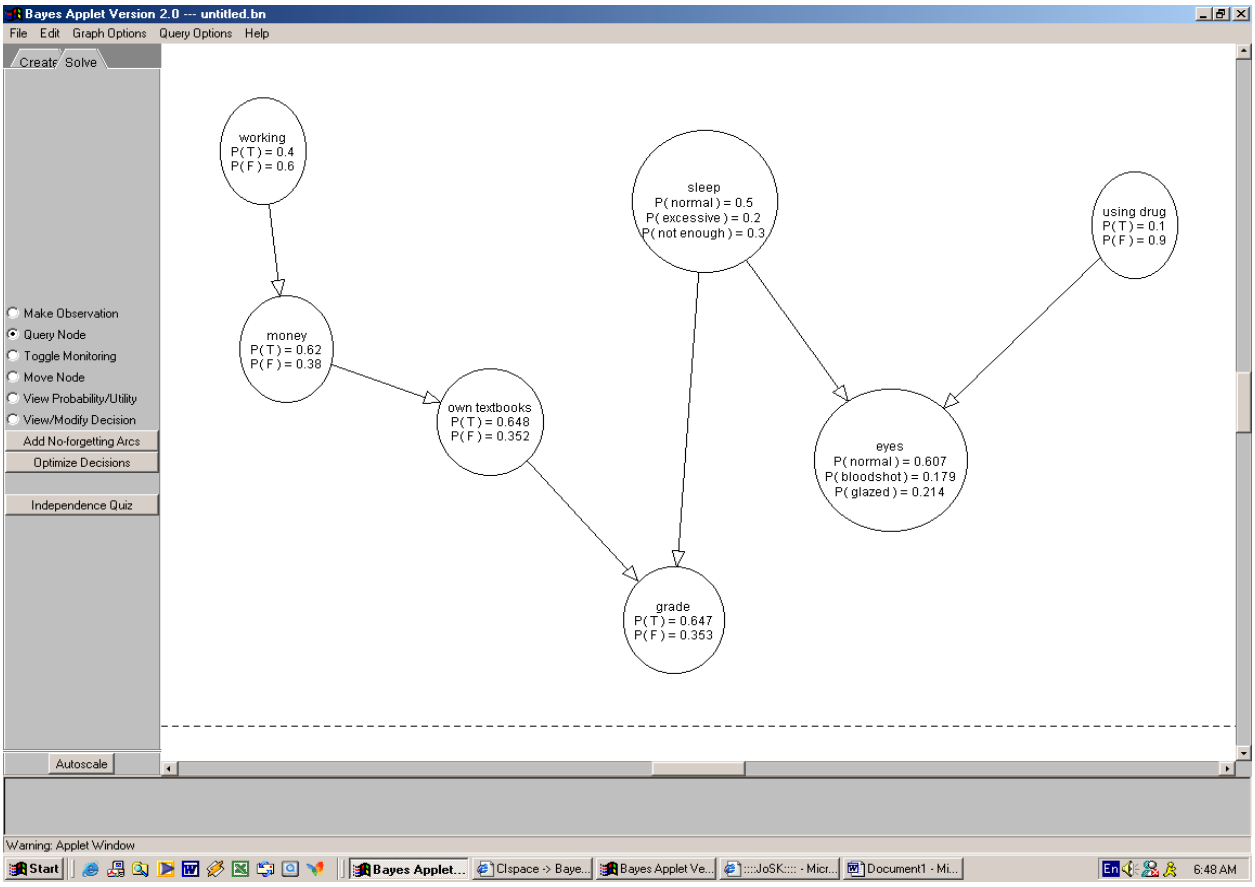
(a) Draw (or print) your complete network, including CPTs.

(b) For your network, evaluate the following queries:

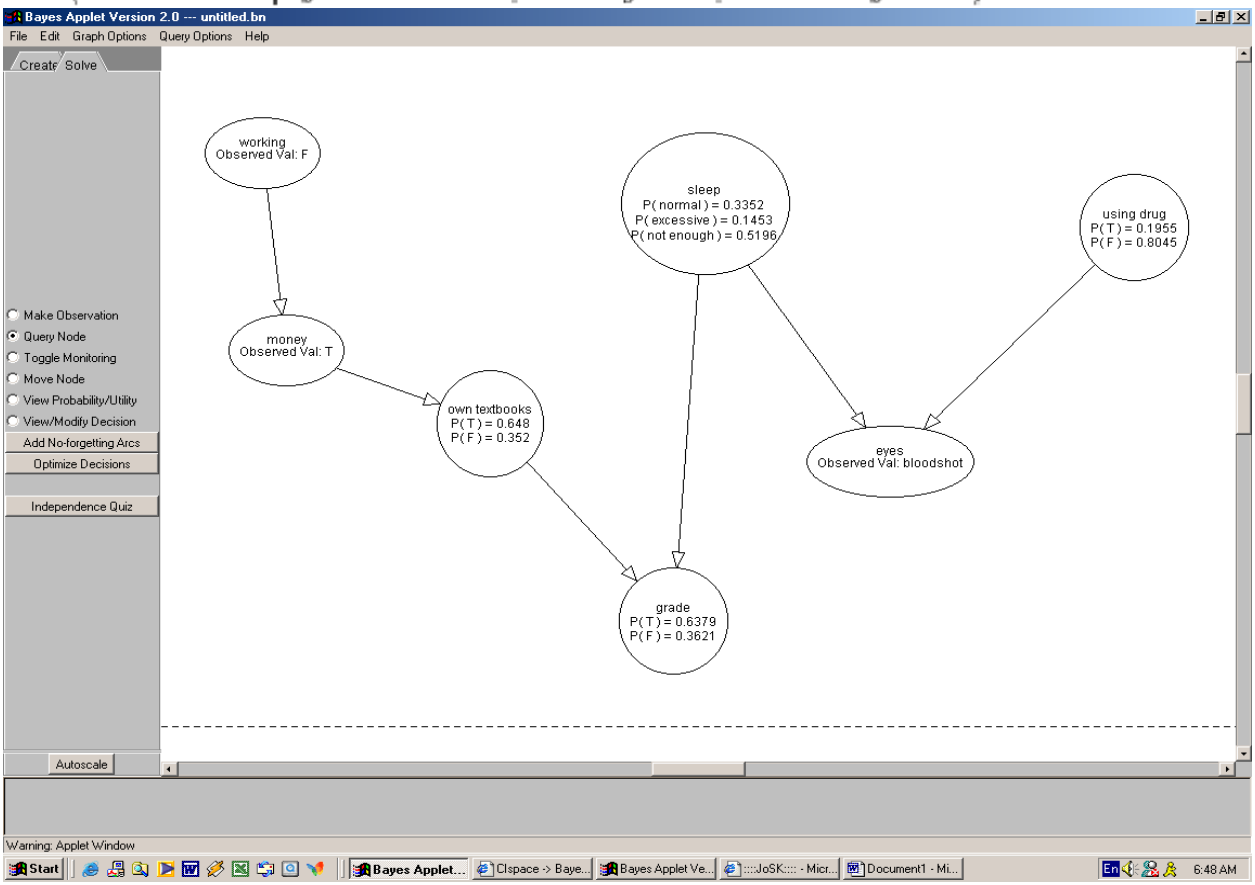
i. $P(Grades = Poor | Eyes = Bloodshot, Working = No, HaveMoney = Yes)$

ii. $P(UsingDrugs = Yes | Eyes = Glazed, HaveMoney = No, Grades = Poor)$

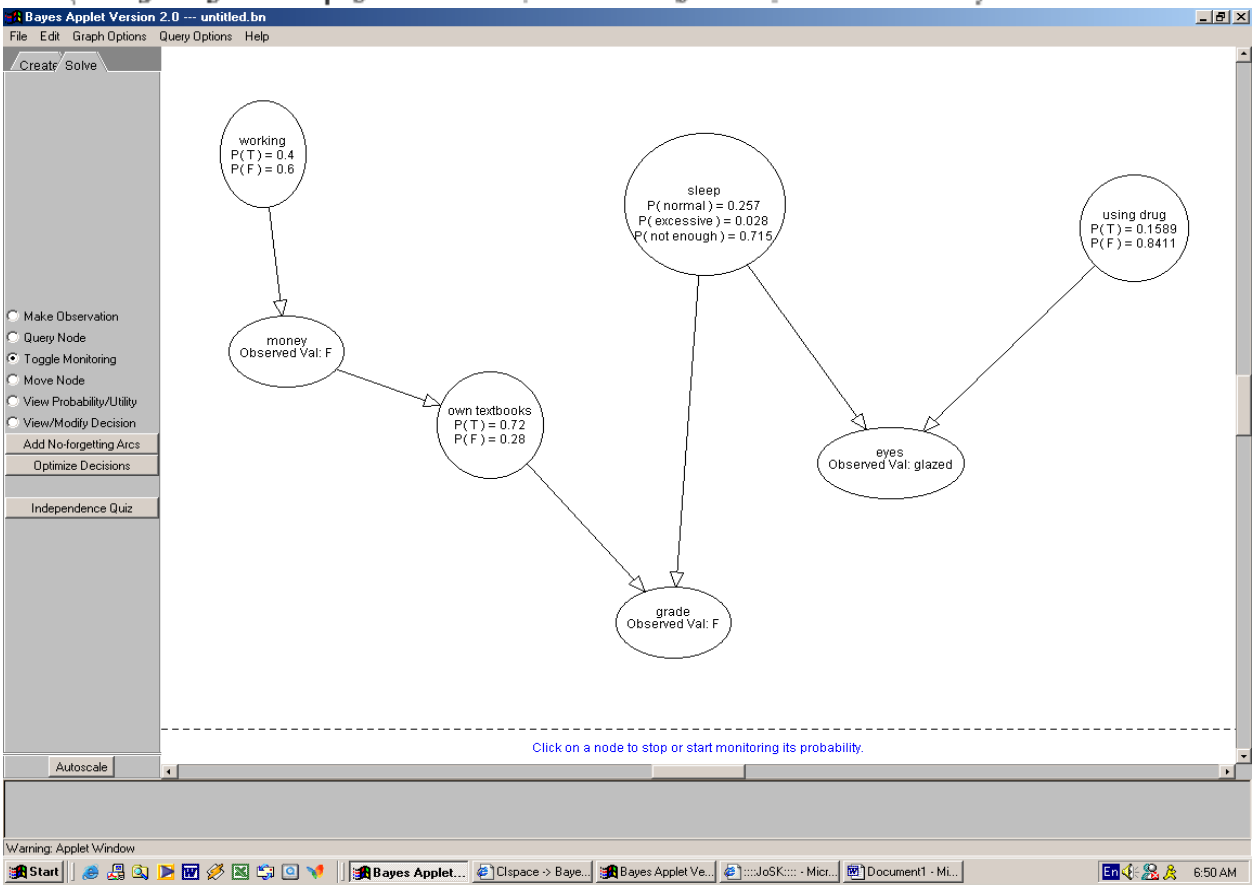
iii. $P(Working = Yes | Eyes = Normal, UsingDrugs = No, Grades = Good)$



i. $P(Grades = Poor | Eyes = Bloodshot, Working = No, HaveMoney = Yes)$



ii. $P(UsingDrugs = Yes | Eyes = Glazed, HaveMoney = No, Grades = Poor)$



iii. $P(Working = Yes | Eyes = Normal, UsingDrugs = No, Grades = Good)$