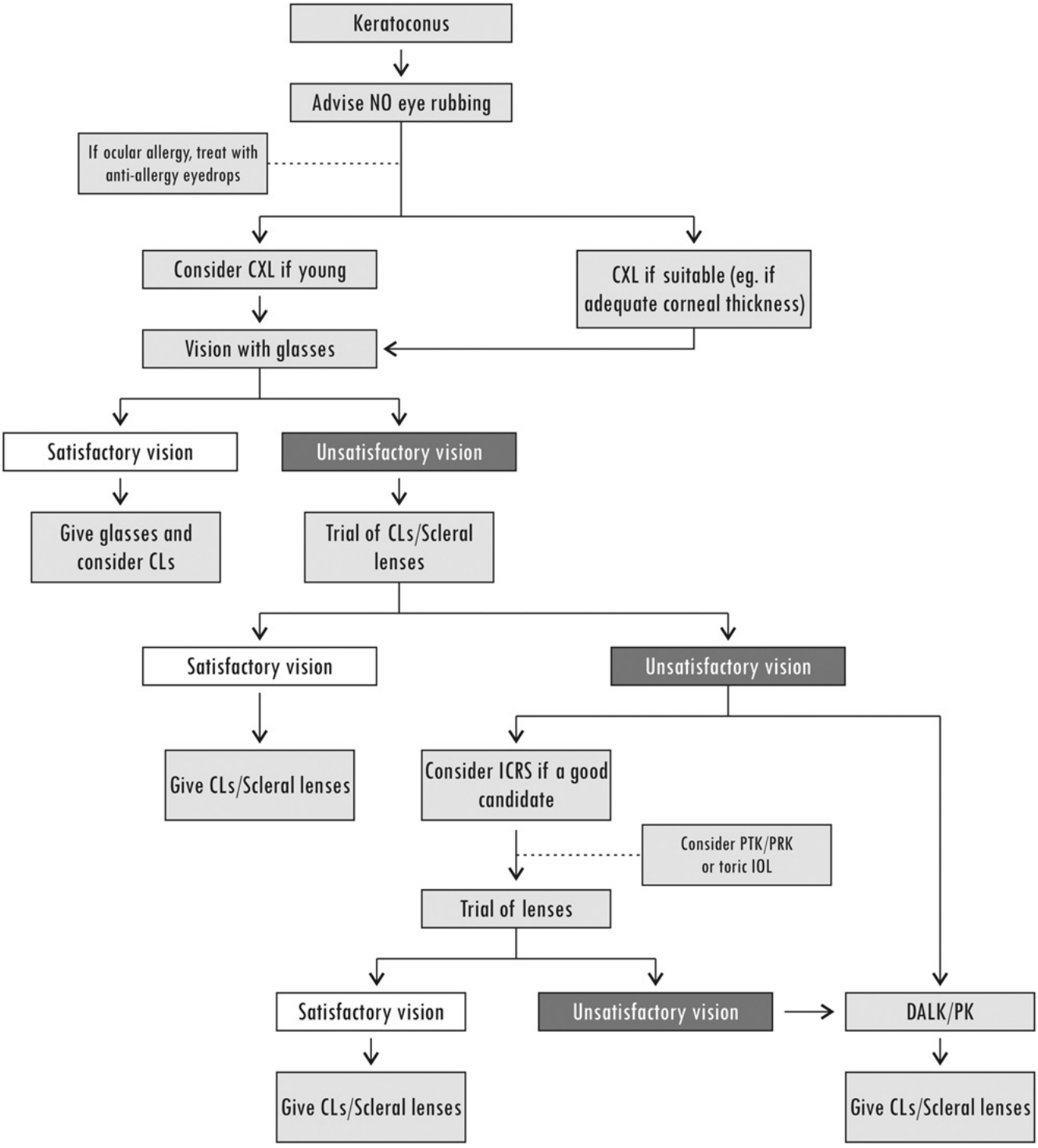
BMEn 2401 – Programming for Biomedical Engineers – Problem Set 3

Due Tuesday, 25 September 2018

1. (20) The figure on the next page is from Gomes *et al.* (*Cornea* 34:359, 2015), describing a strategy for managing keratoconus, an aberrant bulging of the cornea that leads to poor vision. The full paper is on the class Canvas site if you want to read it. Corneal cross-linking (CXL) is a treatment in which a crosslinking agent is applied to the cornea to stiffen it and reduce the bulging. An intracorneal ring segment (ICRS), a support structure placed inside the cornea, is another option, as are contact lenses (CL) and intraocular lenses (IOL). Photorefractive keratotomy (PRK) and deep anterior lamellar keratotomy (DALK) are other surgical options. This is a rough scheme based on the flowchart, with the lines number for reference in the questions below.

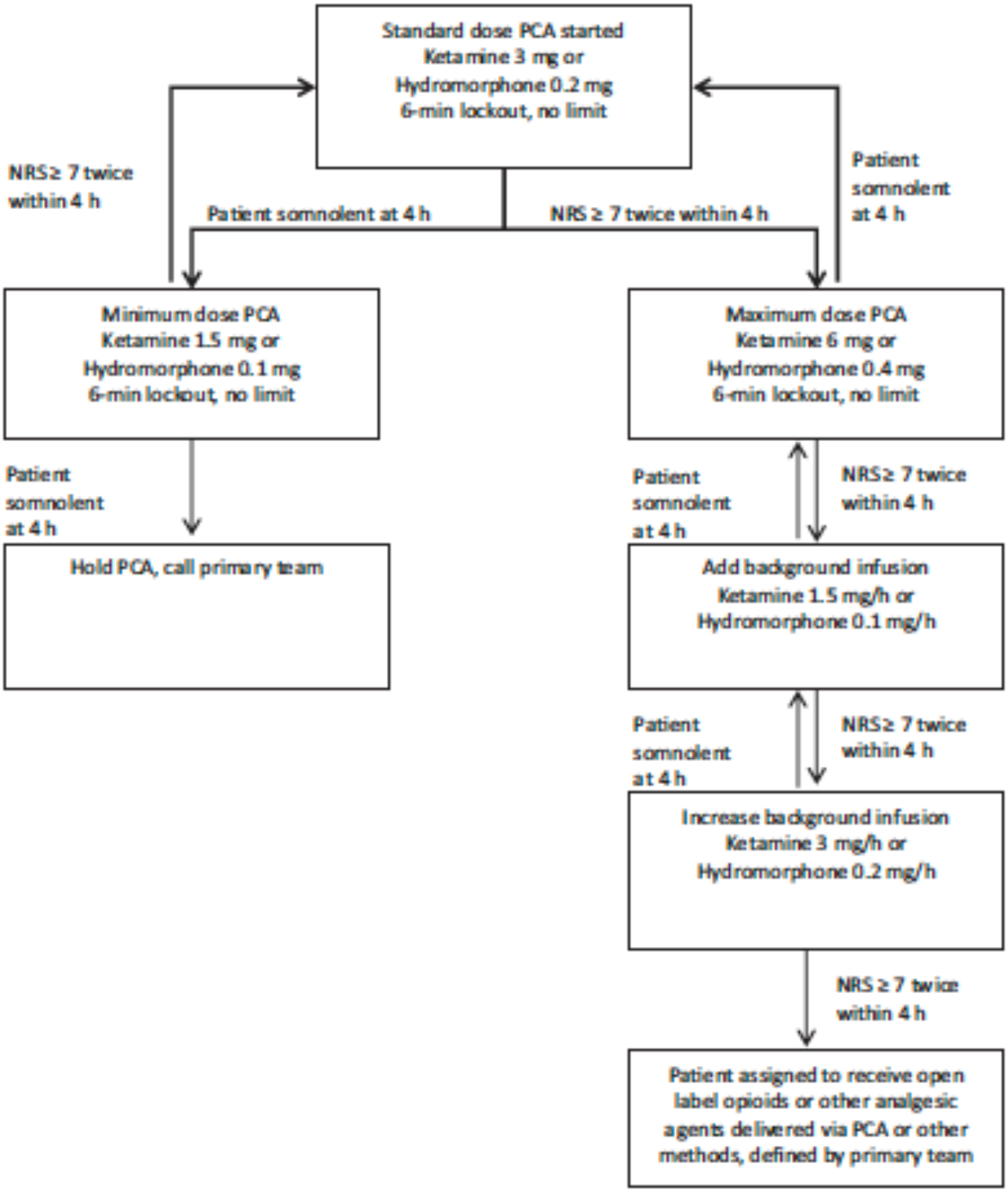
```
1     <Advise no eye rubbing>
2     if <____>
3           then <____>
4     end if
5     if <suitable for CXL>
6     <Do CXL>
7     <Check vision with glasses>
8     if <it's satisfactory>
9           <Give glasses>
10    else
11          <Try ICRS>
12          if <vision is still unsatisfactory>
13                <Try CL>
14                if < vision is still unsatisfactory >
15                      <Try ___>
16                end if
17          end if
18    end if
19    <Give CL / Scleral lenses>
```

a. What goes in the blanks in lines 2 and 3?
b. What goes in the blank in line 15?
c. Two of the first 18 lines need to be switched in the scheme. Which two?
d. Line 19 could be left where it is or could be moved up ahead of the *end if* in line 18. Would you leave it, move it, or do something else, and why?


Keratoconus
Advise NO eye rubbing
If ocular allergy, treat with anti-allergy eyedrops
Consider CXL if young
CXL if suitable (eg. if adequate corneal thickness)
Vision with glasses
Satisfactory vision
Unsatisfactory vision
Give glasses and consider CLs
Trial of CLs/Scleral lenses
Satisfactory vision
Unsatisfactory vision
Give CLs/Scleral lenses
Consider ICRS if a good candidate
Consider PTK/PRK or toric IOL
Trial of lenses
Satisfactory vision
Unsatisfactory vision
DALK/PK
Give CLs/Scleral lenses
Give CLs/Scleral lenses

2. (20) The figure on the next page is taken from the paper "Ketamine versus hydromorphone patient-controlled analgesia for acute pain in trauma patients" (Takieddine *et al., J. Surg. Res.* 225:6, 2018); the full paper is available on the class Canvas site if you want to look at it (sorry, by the way, about the resolution on this document; it's better in the full pdf). The algorithm is designed to manage the dosage of pain killers in a patient-controlled analgesia (PCA) setting. I called each box on the diagram a state, starting with state 1 on the lower left and going around clockwise to state 7 on the lower right. There are, however, a number of blanks in the pseudocode. Figure out how the code works and put in the appropriate items in each blank. (NOTE: Next week, we will learn the Matlab format for while loops and if/then/else statements; for now, we only need to know that such statements exist, not how to code them).

PCAvect = [__ __ __ __ __ __ __];
BGvect = [__ __ __ __ __ __ __];
state = 3;
while (state > __) and (state < __)
    wait 4 hr and check on the patient
    if the patient is asleep (somnolent),
        then _____
    else if the patient rates his/her pain at least a 7 (NRS),
        then _____
    end if
    set PCA = PCAvect [state]
    set BG = BGvect [state]
end while
if state == 1
    then ___
else
    ___
end


Standard dose PCA started
Ketamine 3 mg or
Hydromorphone 0.2 mg
6-min lockout, no limit
NRS ≥ 7 twice within 4 h
Patient somnolent at 4 h
NRS ≥ 7 twice within 4 h
Patient somnolent at 4 h
Minimum dose PCA
Ketamine 1.5 mg or
Hydromorphone 0.1 mg
6-min lockout, no limit
Maximum dose PCA
Ketamine 6 mg or
Hydromorphone 0.4 mg
6-min lockout, no limit
Patient somnolent at 4 h
Hold PCA, call primary team
Patient somnolent at 4 h
NRS ≥ 7 twice within 4 h
Add background infusion
Ketamine 1.5 mg/h or
Hydromorphone 0.1 mg/h
Patient somnolent at 4 h
NRS ≥ 7 twice within 4 h
Increase background infusion
Ketamine 3 mg/h or
Hydromorphone 0.2 mg/h
NRS ≥ 7 twice within 4 h
Patient assigned to receive open label opioids or other analgesic agents delivered via PCA or other methods, defined by primary team

3. (15) The data file *Shoulder.txt* contains a tab-delimited 1879 x 2 matrix, whose first column corresponds to frame number for an image of shoulder motion, and who second column corresponds to the shoulder elevation in degrees based on that frame (Note: the elevation is negative when the arm goes up because of the way they drew their axes). The data were collected at 30 fps by my colleague Paula Ludewig, who has graciously allowed us to use them. I would like to calculate the slope of the segment of the data between t = 7 and t = 12 seconds. Here is a plan to do that in a very sparse pseudocode

*Read the data into an array using **dlmread.** NOTE: You will need to use dlmread('Shoulder.txt','\t') to tell Matlab that data are separated by tabs, not commas.*
Extract lines 210-360 from each column of S into vectors fv and ev, respectively. You will want to use the colon to describe the range of interest. Refer to section 6.1.5 of the text for a description of the colon operator if you are not sure of what to do.
*Construct a new matrix A whose first column is 151 ones and whose second column is equal to fv (i.e., so A(1,2) = fv(1,1), etc.). If you write **A(1:151,1) = ones(151,1)**, it will put 151 ones into the first column of A as desired.*
*The linear fitting problem is now A*x = ev. Solve the problem by linear least squares. You may recall from the last homework that this can be solved by the line x = (A'*A) \ (A'*ev);.*
The slope is x(2,1) - NOTE: The intercept is x(1,1).

The plan is slightly flawed because it will calculate the slope in degrees per frame, not degrees per second. Write a Matlab routine to implement the plan *and include a correction for frame rate.*

4. (15) The file *GaitHip.txt* contains a tab-delimited 101 x 2 matrix, whose first column is the angle of the hip (in degrees) measured for someone walking, and whose second column is the calculated angular velocity (in degrees per second) of the hip. The time unit for these data is the % of the gait cycle (the gait cycle is the period from some point, e.g., when the right heel first strikes the ground, to then the same point occurs again). I would like to know how long the subject's gait cycle took. Knowing that velocity is distance per time, I can calculate the time for each step by rearranging the approximation

$v_i = (x_i - x_{i-1}) / (dt)$

where v_i is the velocity at time point i, x_i is the angle at time point i, and dt is the time step between measurements (which, in our case, we know is 1% of the total gait cycle). Write a Matlab script to

*Read in GaitHip.txt to an array hip using **dlmread**.*
Create a 100 x 1 vector xold equal to the first 100 elements of the first column of hip.
Create a 100 x 1 vector xnew equal to the last 100 elements of the first column (i.e., elements 2,1 through 101,1) of hip.
Create a new vector v2 given by the difference of xnew and xold.
Use the ./ command to create a new vector t whose values are given by
t(i,1) = (xnew(i,1)-xold(i,1))/hip(i,2)
This operation is most effectively done using the ./ operator. Refer to section 2.5.7 of the text for a description of the ./ operator
Calculate the average value of the t by using the function mean(t).
Use this value to estimate the time of the entire gait cycle.

5. (30) The figure on the next page is a lung function questionnaire from Hanania *et al.* (*Resp. Med.* 104:1160, 2010; the paper is available on the Canvas site). Write a Matlab script to administer the quiz and conclude with a direction to the subject, with the following changes:

(1) Although I understand why they did it, it makes no sense to me to have "Never Smoked" or "Never Cough Up Mucus" to be marked as 5's. Remake the numbers on questions 1-3 so that a 0 indicates never and 4 indicates "Very Often." Of course, you will need to do some internal manipulations to get the total scoring system to work correctly.
(2) For question (4), the subject should be able to enter how many years s/he has been smoking. Implement an *input* command that asks for years of smoking, and then use the Matlab *floor* (or *ceil*) and *max* (and/or *min*) functions (you may need to consult the help documentation) to convert years of smoking into the correct score for the question.
(3) Likewise, for question (5), age should be entered as a number (e.g., my age is 52, not 50-59 years). Again, use some combination of *floor*, *ceil*, *max*, and *min* to convert an age to a score.
(4) At the end, you'll need to use a conditional statement. These are pretty simple and are covered in Lecture 7, but in case you don't have time to watch Lecture 7 before working on this problem, the following statement (modified to fit your variables) would work:

```
if (score <= 18)
     disp ('You are at high risk for COPD');
else
     disp ('You are at low risk for COPD');
end
```

Lung Function Questionnaire

Do you suffer from breathing problems and/or frequent cough?

These questions ask about your breathing problems and/or frequent cough. As you answer these questions, please think about how you are feeling physically when you are experiencing these symptoms. For each question, choose the one answer that best describes your symptoms. Share the answers with your doctor.

Step 1: Answer each question and write the score in the box provided next to it.
Step 2: Add the score boxes for your total score
Step 3: Take the test to the doctor to talk about your score

										SCORE
1. How often do you cough up mucus?	Never	5	Rarely	4	Sometimes	3	Often	2	Very Often 1	
2. How often does your chest sound noisy (wheezy, whistling, rattling) when you breathe?	Never	5	Rarely	4	Sometimes	3	Often	2	Very Often 1	
3. How often do you experience shortness of breath during physical activity (walking up a flight of stairs or walking up an incline without stopping to rest)?	Never	5	Rarely	4	Sometimes	3	Often	2	Very Often 1	
4. How many years have you smoked?	Never Smoked	5	10 years or less	4	11-20 years	3	21-30 years	2	More than 30 years 1	
5. What is your age?	Less than 40 years	5	40-49 years	4	50-59 years	3	60-69 years	2	70 years or older 1	
										TOTAL

Step 4: If your score is <u>18 or less</u> then you may be at risk for Chronic Obstructive Pulmonary Disease (COPD) which includes chronic bronchitis, emphysema or both. Ask your doctor if you need a simple breathing test. This questionnaire is intended to determine your risk of COPD. No matter what your score, you should still ***talk to your doctor*** about your symptoms.