Final EXAMINATION
December 2019

DURATION: 3 HOURS
No. of Students: 42
Department Name & Course Number: Systems and Computer Engineering SCE 4203
Course Instructor(s): Andy Adler

AUTHORIZED MEMORANDA
1) One 8.5” × 11” sheet of notes (double sided),
2) A Non network-connected calculator

Students MUST count the number of pages in this examination question paper before beginning to write, and report any discrepancy to a proctor. This question paper has 16 pages (including the cover page).

This examination question paper MAY NOT be taken from the examination room.

In addition to this question paper, students require: an examination booklet yes no
a scantron sheet yes no

Please print your name and student number in the boxes below:

Family Name | First Name | Student Number
-------------|------------|-----------------

Instructions:
- This test has 16 pages and 5 questions. Answer all questions and subparts. Marks are indicated.
- You have 180 minutes to complete this exam.
- Answers should be written in this exam document. Write your answers in the space provided. If you require more space, use the back of exam pages, and indicate that extra space was used.
- All electronics components may be assumed ideal, unless stated otherwise.

| # | Mark | 1 | 1A | 1B | 2 | 2A | 2B | 2C | 3 | 3A | 3B | 3C | 4 | 4A | 4B | 4C | 4D | 5 | 5A | 5B | 5C |
|---|------|---|----|----|---|----|----|----|---|----|----|----|---|----|----|----|---|---|---|---|
|   | Mark | 1 | 1A | 1B | 2 | 2A | 2B | 2C | 3 | 3A | 3B | 3C | 4 | 4A | 4B | 4C | 4D | 5 | 5A | 5B | 5C |
**Background:** Atrial fibrillation (AF) is an abnormal heart rhythm characterized by rapid and irregular beating of the atrial chambers of the heart. It is associated with an increased risk of heart failure, dementia, and stroke. Atrial fibrillation is the most common serious abnormal heart rhythm, affecting 2–3% of the population in Europe and North America\(^1\).

AF is often treated with medications, which have side effects. An increasingly common treatment is radiofrequency (RF) catheter ablation, a medical procedure in which a catheter is introduced into the heart through the veins, and then a dysfunctional part of the electrical conduction system of the heart is ablated (destroyed) using the heat generated from medium frequency alternating current (≈ 500 kHz)\(^3\).

An RF ablation catheter is shown in Fig 1. This catheter works in two modes:
- Biopotential recording — measure the heart muscle
- Ablation — injecting large currents into the tissue

The catheter ablation procedure is not always successful; one study\(^4\) found 52% of patients successfully maintained normal heart rhythms after 2 years. In order to determine whether AF treatment is successful, several different monitoring methods are used. One promising technique is analysis of heart-rate variability (HRV), as illustrated by a recent study\(^5\) which showed that lower overall HRV was associated with a higher risk of AF.

Obstructive sleep apnea (OSA) is a common sleep disorder in which the upper airways close or narrow repeatedly during sleep.\(^6\) OSA is highly correlated with AF, although the mechanisms are poorly understood; possible explanations focus on the repeated breathing against a closed glottis creating negative pressures in the thorax which place a stress on the heart, and that the reduced blood oxygen concentration leads to sympathetic activation driving heart-rate elevation\(^7\).

**Scenario:** After graduation, you are employed as a test engineer in a medical devices company which builds RF catheter ablation technology. They are working on a HRV-based monitoring technology which will be used to study the patients in the time after their procedure to determine whether it was a success. You are required to understand the ablation technology and help develop the HRV-based monitoring system.

---

\(^1\)https://en.wikipedia.org/wiki/Atrial_fibrillation  
\(^3\)https://en.wikipedia.org/wiki/Radiofrequency_ablation  
\(^4\)Yubing et al, “Long-term outcome of radiofrequency catheter ablation for persistent atrial fibrillation” Medicine (Baltimore), 97:e11520, 2018  
\(^5\)Agarwal et al, “Cardiac Autonomic Dysfunction and Incidence of Atrial Fibrillation: Results From 20 Years Follow-Up” J Am Col Cardiology 69:291–299, 2017  
\(^6\)https://en.wikipedia.org/wiki/Obstructive_sleep_apnea  