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Strive for Distinctiveness
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BIOCONTROL SYSTEMS FOR BIOMEDICAL TECHNICIAN – TDBE 2107

OIST Online · Engineering & Applied Sciences · course outline
Issued 22 November 2026

Level	**Intermediate**
Duration	**3 months**
Weekly effort	**About 6 hours a week (75 hours over 13 weeks)**
Content	**7 modules · 106 lessons · 69 h 41 min**
Format	**Online, self-paced**
Fee	**UGX 50,000**
Certificate	**Professional Certificate**
Instructor	**Eng. Emmanuel Ogwang, Biomedical Engineer, Oyam Institute of Sciences and Technology**

How the body and medical machines keep things under control. Model, analyse, stabilise and compensate biocontrol systems, from blood glucose to ventilators. Short videos, 3D models, worked UVTAB scenarios and labs, at your own pace, ending with an exam clinic built from five past papers.

WHAT YOU WILL LEARN

- Identify the basic elements of a control system and classify open-loop and closed-loop biocontrol systems
- Describe physiological regulation (blood glucose, body temperature, cardiac output, neuromuscular reflex) as feedback control and draw its block diagram
- Model mechanical and thermal systems and draw their force–voltage and force–current electrical analogues
- Derive transfer functions from differential equations using Laplace transforms
- Reduce block diagrams step by step to a single closed-loop transfer function
- Describe the impulse, step, ramp and parabolic test signals mathematically
- Analyse first- and second-order time responses and calculate time constant, rise time, peak time, percentage overshoot and settling time
- Calculate error constants (Kp, Kv, Ka), the generalised error series and steady-state error for type 0, 1 and 2 systems
- Sketch Bode plots and determine gain margin, phase margin and the gain and phase crossover frequencies
- Sketch polar plots and read gain margin and phase margin from them
- Find resonant peak, resonant frequency and bandwidth from the open-loop response and compare

frequency-domain and time-domain analysis
- Form the characteristic equation and judge stability from the location of its roots in the s-plane
- Apply the Routh–Hurwitz criterion, including its special cases
- Draw Nyquist plots and apply the Nyquist stability criterion
- Design lag, lead and lag-lead compensators using Bode plots and derive their RC network transfer functions
- Simulate step and impulse responses of type 0, 1 and 2 systems in MATLAB, Simulink and PSPICE
- Measure a first-order step response on a CRO and calculate its performance specifications
- Answer UVTAB scenario-based Biocontrol Systems questions with confidence

REQUIREMENTS

- Enrolled in the OIST Diploma in Biomedical Engineering (or a related diploma)
- Electrical Engineering Science (RLC circuits) and basic engineering mathematics: complex numbers, differentiation and integration. Laplace transforms are revised in Week 1
- A non-programmable scientific calculator, a table of Laplace transforms, graph paper and semi-log graph paper
- A smartphone or computer with about 1–2 GB of internet a month
- A free MathWorks account for the MATLAB and Simulink Onramp courses
- Access to MATLAB (Control System Toolbox and Simulink) and PSPICE or LTspice for the simulation labs
- Access to the OIST laboratory (CRO, function generator, RC components) for the hardware practical

ABOUT THIS COURSE

About this course

Every life-support machine in a hospital is a control system. An infant incubator holds the baby's temperature steady. An infusion pump delivers a drug at a set rate. A ventilator delivers the set pressure with every breath. Each one measures what is happening, compares it with what should happen and corrects the difference. The human body works the same way: insulin and glucagon hold blood glucose steady, the baroreflex holds blood pressure steady and the stretch reflex holds a limb in place.

Biocontrol Systems (TDBE 2107) gives you the engineering tools to describe all of these: you will turn a biological or medical system into a mathematical model, predict its response, test its stability and design a compensator that makes it perform better. The course follows the UVTAB syllabus for the Diploma in Biomedical Engineering (4 credit units: 45 lecture hours and 30 practical hours).

What you will study

Weeks

Unit

Content

1–3

1. Systems and their representation

Biocontrol systems and their elements; open and closed loop; glucose, heart-rate, cardiac-output and reflex loops; transfer functions; mechanical, electrical and thermal models and analogies; block diagram reduction

4–5

2. Time response analysis

Test signals; first- and second-order responses; time-domain specifications; error constants, generalised error series and steady-state error

6–8

3. Frequency response analysis

Frequency-domain specifications; Bode plots; gain and phase margins; polar plots; closed-loop from open-loop response; time vs frequency domain

9–10

4. Stability

Characteristic equation; s-plane; Routh–Hurwitz; Nyquist criterion

11–12

5. Compensator design

Lead, lag and lag-lead networks; design using Bode plots

Throughout

6. Practical and simulation labs

MATLAB/Simulink, LTspice or PSPICE; first-order step response on a CRO; type 0, 1 and 2 responses

13

7. UVTAB exam clinic

Answering technique, scenario versions of all five papers with model answers, and timed mocks

How you will learn

The course is fully self-paced, with no live classes. Each week has short video lessons from respected control engineering teachers, brief illustrated notes that go straight to the point, step-by-step worked scenarios set out the way UVTAB marks them, a 3D model where seeing the real organ or device helps, and a quiz with instant feedback. Each unit ends with a timed test, and there is an assignment every month.

Assessment

Quizzes, unit tests, assignments and lab reports form your continuous assessment at OIST. The final examination is set and marked by UVTAB: a 3-hour paper of eight questions, of which you answer five, plus the practical and project assessments UVTAB sets each semester.

Core references

Nise, N. S. Control Systems Engineering, 8th ed. Wiley, 2019.

Ogata, K. Modern Control Engineering. Pearson / PHI (4th ed. or later).

Nagrath, I. J. and Gopal, M. Control Systems Engineering. New Age International.

Kuo, B. C. Automatic Control Systems. Pearson Education.

Ghosh, S. Control Systems: Theory and Applications. Pearson Education.

Gopal, M. Control Systems: Principles and Design. Tata McGraw-Hill.

Khoo, M. C. K. Physiological Control Systems: Analysis, Simulation, and Estimation, 2nd ed. Wiley-IEEE Press,

2018.

Free online tools you will use

Simulink Onramp (MathWorks, free)

Control Design Onramp with Simulink (MathWorks, free)

Submitting your work

Send all assignments and lab reports to info@oist.ac.ug with your name, registration number and the assignment title in the subject line.

COURSE CONTENT

Module 1 · BCS-U1 · Unit 1 — Systems and Their Representation

Weeks 1–3 (8 hours). Biocontrol systems and their basic elements; open and closed loop; classification; physiological loops (blood glucose, heart rate, cardiac output, neuromuscular reflex); transfer function; modelling electrical and mechanical systems; force–voltage and force–current analogies; block diagram reduction.

#	LESSON	TYPE	MINUTES
1	Unit 1 · Overview	Reading	3
2	Week 1 · What is a control system? (video)	Video	20
3	Week 1 · Notes: Biocontrol systems, elements and classification	Reading	25
4	Week 1 · Open-loop and closed-loop systems (video)	Video	18
5	Week 1 · Closed loop at the bedside: the infusion pump (3D)	3D model	8
6	Week 1 · Notes: The human body as a control system	Reading	30
7	Week 1 · Blood glucose regulation (video)	Video	6
8	Week 1 · The baroreceptor reflex (video)	Video	4
9	Week 1 · The heart in 3D: where cardiac output comes from	3D model	8
10	Week 1 · Quiz	Quiz	12
11	Week 2 · Transfer functions (video)	Video	12
12	Week 2 · Notes: Transfer functions and mathematical modelling	Reading	35
13	Week 2 · Modelling electrical systems (video)	Video	20
14	Week 2 · Modelling mechanical translational systems (video)	Video	20
15	Week 2 · Force–voltage and force–current analogy (video)	Video	20
16	Week 2 · Spring, mass and damper in 3D	3D model	6
17	Week 2 · Analogy worked examples (video)	Video	22
18	Week 2 · Worked scenarios: modelling and analogies (UVTAB 2022, 2024)	Reading	40
19	Week 2 · Quiz	Quiz	12

#	LESSON	TYPE	MINUTES
20	Week 3 · Block diagram algebra and reduction rules (video)	Video	22
21	Week 3 · Notes: Block diagrams and reduction rules	Reading	30
22	Week 3 · Block diagram reduction examples (video)	Video	25
23	Week 3 · Worked scenarios: block diagram reduction (UVTAB 2022, 2024)	Reading	45
24	Week 3 · Quiz	Quiz	12
25	Unit 1 · Test (timed)	Quiz	30
26	Assignment 1 · Modelling a neonatal incubator and a rehabilitation rig	Assignment / exam	180

Module 2 · BCS-U2 · Unit 2 — Time Response Analysis

Weeks 4–5 (10 hours). Standard test signals; time response of first- and second-order systems; time-domain specifications; type of a system; static error constants, generalised error series and steady-state error.

#	LESSON	TYPE	MINUTES
1	Unit 2 · Overview	Reading	3
2	Week 4 · Time domain analysis and test signals (video)	Video	20
3	Week 4 · Notes: Test signals and time-domain specifications	Reading	35
4	Week 4 · First-order system responses (video)	Video	18
5	Week 4 · Step response of a second-order system (video)	Video	22
6	Week 4 · Time-domain specifications (video)	Video	20
7	Week 4 · Worked scenarios: analysing a response (UVTAB 2022–2024)	Reading	45
8	Week 4 · Quiz	Quiz	12
9	Week 5 · Steady-state error and error constants (video)	Video	20
10	Week 5 · Notes: Steady-state error and the generalised error series	Reading	30
11	Week 5 · Steady-state error examples (video)	Video	20
12	Week 5 · Quiz	Quiz	12
13	Unit 2 · Test (timed)	Quiz	30

Module 3 · BCS-U3 · Unit 3 — Frequency Response Analysis

Weeks 6–8 (11 hours). Frequency-domain specifications; Bode plots; gain and phase margins and crossover frequencies; polar plots; closed-loop response from open-loop response; frequency domain compared with time domain.

#	LESSON	TYPE	MINUTES
1	Unit 3 · Overview	Reading	3
2	Week 6 · Bode plots: introduction (video)	Video	10
3	Week 6 · Notes: Frequency response and constructing Bode plots	Reading	40
4	Week 6 · Bode plots by hand: real poles and zeros (video)	Video	13
5	Week 6 · Frequency-domain specifications (video)	Video	18
6	Week 6 · Asymptotic Bode plot (video)	Video	22
7	Week 6 · Quiz	Quiz	12
8	Week 7 · Gain and phase margins explained (video)	Video	13
9	Week 7 · Stability analysis using Bode plots (video)	Video	20
10	Week 7 · Notes: Margins and the Bode stability criterion	Reading	20
11	Week 7 · Worked scenarios: Bode plots and margins (UVTAB 2022–2024)	Reading	50
12	Week 7 · Bode plot numerical example (video)	Video	22
13	Week 7 · Quiz	Quiz	12
14	Week 8 · Polar plot: concept and procedure (video)	Video	20
15	Week 8 · Notes: Polar plots and closed-loop response	Reading	35
16	Week 8 · Polar plot numerical example (video)	Video	20
17	Week 8 · Worked scenarios: polar plots (UVTAB 2022, 2023)	Reading	40
18	Week 8 · Time and frequency domain correlation (video)	Video	18
19	Week 8 · Quiz	Quiz	12
20	Unit 3 · Test (timed)	Quiz	35
21	Assignment 2 · Time and frequency response of a neonatal ventilator loop	Assignment / exam	240

Module 4 · BCS-U4 · Unit 4 — Stability of Control Systems

Weeks 9–10 (8 hours). Stability; characteristic equation; location of roots in the s-plane; Routh–Hurwitz criterion and special cases; Nyquist stability criterion.

#	LESSON	TYPE	MINUTES
1	Unit 4 · Overview	Reading	3
2	Week 9 · The concept of stability (video)	Video	18
3	Week 9 · Notes: Stability, the s-plane and Routh–Hurwitz	Reading	40
4	Week 9 · Routh–Hurwitz criterion: an introduction (video)	Video	13

#	LESSON	TYPE	MINUTES
5	Week 9 · Routh–Hurwitz stability test, worked (video)	Video	20
6	Week 9 · Routh–Hurwitz special cases (video)	Video	13
7	Week 9 · Worked scenarios: Routh–Hurwitz (UVTAB 2023, 2024)	Reading	40
8	Week 9 · Quiz	Quiz	12
9	Week 10 · Nyquist stability criterion (video)	Video	12
10	Week 10 · Nyquist plot and Nyquist theorem (video)	Video	20
11	Week 10 · Notes: The Nyquist stability criterion	Reading	30
12	Week 10 · Nyquist numerical example (video)	Video	20
13	Week 10 · Worked scenarios: Nyquist (UVTAB 2022, 2023, 2024)	Reading	40
14	Week 10 · Quiz	Quiz	12
15	Unit 4 · Test (timed)	Quiz	30

Module 5 · BCS-U5 · Unit 5 — Compensator Design

Weeks 11–12 (8 hours). Purpose of compensators; lead, lag and lag-lead RC networks, transfer functions, pole–zero plots and Bode plots; lag and lead compensator design using Bode plots.

#	LESSON	TYPE	MINUTES
1	Unit 5 · Overview	Reading	3
2	Week 11 · What are lead and lag compensators? (video)	Video	11
3	Week 11 · Notes: Compensators and their RC networks	Reading	40
4	Week 11 · Worked scenarios: compensator networks (UVTAB 2023, 2024)	Reading	30
5	Week 11 · Quiz	Quiz	12
6	Week 12 · Notes: Designing lag and lead compensators with Bode plots	Reading	30
7	Week 12 · Designing a lead compensator with the Bode plot (video)	Video	14
8	Week 12 · Worked scenarios: lag compensator design (UVTAB 2023, 2024)	Reading	50
9	Week 12 · Worked scenario: lead compensator design (UVTAB 2022)	Reading	35
10	Week 12 · Quiz	Quiz	15
11	Unit 5 · Test (timed)	Quiz	30
12	Assignment 3 · Compensating a dialysis-machine temperature loop	Assignment / exam	240

Module 6 · BCS-U6 · Unit 6 — Practical and Simulation Labs

30 practical hours. Lab 1: MATLAB Control System Toolbox, Simulink and LTspice/PSPICE. Lab 2: first-order step response on a CRO and its specifications. Lab 3: step and impulse responses of type 0, 1 and 2 unity-feedback systems.

#	LESSON	TYPE	MINUTES
1	Unit 6 · Overview and lab rules	Reading	10
2	Lab 1 · Getting started with MATLAB, Simulink and LTspice	Reading	120
3	Lab 1 · Report	Assignment / exam	60
4	Lab 2 · The cathode-ray oscilloscope in 3D	3D model	8
5	Lab 2 · Step response on the CRO: first- and second-order systems	Reading	180
6	Lab 2 · Report	Assignment / exam	60
7	Lab 3 · Type 0, 1 and 2 systems: step and impulse responses	Reading	180
8	Lab 3 · Report	Assignment / exam	60

Module 7 · BCS-U7 · Unit 7 — UVTAB Exam Clinic

Week 13. How UVTAB questions are set and marked; topic frequency across five past papers; scenario-based versions of every past question with full model answers; timed mock examinations.

#	LESSON	TYPE	MINUTES
1	Unit 7 · Overview	Reading	3
2	Exam guide: how UVTAB sets and marks Biocontrol Systems	Reading	20
3	Scenario Paper A (based on Nov/Dec 2022)	Reading	180
4	Scenario Paper A · Model answers	Reading	60
5	Scenario Paper B (based on May/June 2024)	Reading	180
6	Scenario Paper B · Model answers	Reading	60
7	Scenario Paper C (based on Nov/Dec 2024)	Reading	180
8	Scenario Paper C · Model answers	Reading	60
9	Scenario Paper D (based on April/May 2023, Sets 1 and 2)	Reading	180
10	Scenario Paper D · Model answers	Reading	60
11	Final mock examination (timed)	Quiz	60

Enrol online at www.oist.ac.ug/online/ggOwJGgE3MgfwhVzTAK9. Learn at your own pace on your phone or computer, and earn a certificate anyone can verify with its QR code.