#44853

Office of the Registrar
FORM 40G REV. 10/10

PURDUE UNIVERSITY

REQUEST FOR ADDITION, EXPIRATION, OR REVISION OF A GRADUATE COURSE
(50000-60000 LEVEL)

Print Form

Graduate Council Doc. 12-3b
EFD 17-12

ARTMENT Civil Engineering

EFFECTIVE SESSION Fall 2012 (201310)

INSTRUCTIONS: Please check the items below which describe the purpose of this request.

- [X] 1. New course with supporting documents (complete proposal form)
- [ ] 2. Add existing course offered at another campus
- [ ] 3. Expiration of a course
- [ ] 4. Change in course number
- [ ] 5. Change in course title
- [ ] 6. Change in course credit/type
- [ ] 7. Change in course attributes
- [ ] 8. Change in instructional hours
- [ ] 9. Change in course description
- [ ] 10. Change in course requisites
- [ ] 11. Change in semesters offered
- [ ] 12. Transfer from one department to another

PROPOSED:		EXISTING:	
Subject Abbreviation	CE	Subject Abbreviation	
Course Number	~~51400~~ 51401	Course Number	
Long Title	Building Controls		
Short Title	Building Controls		

Abbreviated title will be entered by the Office of the Registrar if omitted. (30 CHARACTERS ONLY)

TERMS OFFERED
Check All That Apply:
[X] Fall [X] Spring [ ] Summer

CAMPUS(ES) INVOLVED
[ ] Calumet [ ] N. Central
[ ] Cont Ed [ ] Tech Statewide
[ ] Ft. Wayne [X] W. Lafayette
[ ] Indianapolis

CREDIT TYPE
1. Fixed Credit: Cr. Hrs. 3
2. Variable Credit Range:
Minimum Cr. Hrs
(Check One) To [ ] Or [ ]
Maximum Cr. Hrs.
3. Equivalent Credit: Yes [ ] No [X]
4. Thesis Credit: Yes [ ] No [X]

COURSE ATTRIBUTES: Check All That Apply
1. Pass/Not Pass Only [ ]
2. Satisfactory/Unsatisfactory Only [ ]
3. Repeatable [ ]
Maximum Repeatable Credit: [ ]
4. Credit by Examination [ ]
5. Special Fees [ ]
6. Registration Approval Type
Department [ ] Instructor [ ]
7. Variable Title [ ]
8. Honors [ ]
9. Full Time Privilege [ ]
10. Off Campus Experience [ ]

Schedule Type	Minutes Per Mtg	Meetings Per Week	Weeks Offered	% of Credit Allocated
	50	3	16	100
Lecture				
Recitation				
entation				
oratory				
Lab Prep				
Studio				
Distance				
Clinic				
Experiential				
Research				
Ind. Study				
Pract/Observ				

Cross-Listed Courses

RECEIVED
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2012 MAY -2 AM 9:24

COURSE DESCRIPTION (INCLUDE REQUISITES/RESTRICTIONS):

Restriction: Senior status in the College of Engineering or graduate level standing.
Concurrent prerequisites: (CE 41300 and CE 41400) or graduate standing.

See Attachment for Course Description

Professor Qu.

Calumet Department Head	Date	Calumet School Dean	Date	Calumet Undergrad Curriculum Committee	Date
Fort Wayne Department Head	Date	Fort Wayne School Dean	Date	Fort Wayne Chancellor	Date
Indianapolis Department Head	Date	Indianapolis School Dean	Date	R Cipra Undergrad Curriculum Committee	1/17/2012 Date
North Central Department Head	Date	North Central School Dean	Date	APPROVED 4/26/12 Date Approved by Graduate Council	
M K Banks	11/18/11			Tina K Payne	4/30/12
West Lafayette Department Head	Date	West Lafayette College/School Dean	Date	Graduate Council Secretary	Date
Georg E Lee	4/26/12				
Graduate Area Committee Convener	Date	Graduate Dean	Date	West Lafayette Registrar	Date

OFFICE OF THE REGISTRAR

5/9/12

CE 51401

Form 40 Attachment 1 for **CE ~~51400~~** 51401

CE 51400 BUILDING CONTROLS

Course Description (Include Requisites/Restrictions):
Restriction: Senior status in the College of Engineering or graduate level standing.
Concurrent prerequisites: CE 41300 and CE 41400, or graduate standing.

This course is designed to provide students with the knowledge of fundamentals, design, and analysis for building control systems. It primarily consists of three parts. The first part covers basic concepts, terminology, procedures and computations of control systems including block diagrams & transfer functions, open-loop & closed-loop control, control system modeling, time response, root locus techniques, design via root locus, and digital control systems. The second part focuses on issues surrounding the building controls: interfacing components such as sensors and actuators, problems encountered, and state-of-the-art solutions for building energy efficiency and thermal comfort. The third part aims to develop students' ability to convert control system concepts into real building control systems. The course provides a hands-on opportunity for students to complete three projects associated with the three primary components during the semester: indoor environmental quality assessment, building HVAC system commissioning and its control analysis, and new control algorithm development for building energy efficiency, occupant health, and individual productivity.

Course Learning Outcomes:

After completion of this course students will be able to:

- Demonstrate basic HVAC processes and explain the function, layout, and operation of commercial HVAC systems
- Analyze the function, operating characteristics, and appropriate applications of basic control loops and control modes as found in direct digital, analog electronic, electric and pneumatic commercial control systems
- Understand and program a sequence of control, lay out a control system logic diagram and program it into a DDC controller
- Understand the function of network devices and network protocols such as a bridge, router, gateway, hub, firewall, Ethernet, TCP/IP, BacNet, and Lon Talk.
- Use general-purpose and specific building automation software to monitor and control a building HVAC system.
- Numerically model a building to define the key control parameters for thermal comfort.
- Develop and program alternative control algorithms for building HVAC systems in order to enable sustainable buildings.

CE 51401

Supporting Document for a New Graduate Course

To: Purdue University Graduate Council

From:
Faculty Member: Ming Qu
Department: Civil Engineering
Campus: West Lafayette

Date: 11-28-11

Subject: Proposal for New Graduate Course-Documentation Required by the Graduate Council to Accompany Registrar's Form 40G

For Reviewer's comments only (Select One)

Reviewer:

Comments:

Contact for information if questions arise:
Name: Ming Qu
Phone Number: 494-9125
E-mail: mqu@purdue.edu
Campus Address: CIVL G243

Course Subject Abbreviation and Number: CE ~~51400~~ 51401

Course Title: Building Controls

A. Justification for the Course:

- Provide a complete and detailed explanation of the need for the course (e. g., in the preparation of students, in providing new knowledge/training in one or more topics, in meeting degree requirements, etc.), how the course contributes to existing majors and/or concentrations, and how the course relates to other graduate courses offered by the department, other departments, or interdisciplinary programs.

- Justify the level of the proposed graduate course (50000- or 60000-level) including statements on, but not limited to: (1) the target audience, including the anticipated number of undergraduate and graduate students who will enroll in the course; and (2) the rigor of the course.

B. Learning Outcomes and Method of Evaluation or Assessment:

- Describe the course objectives and student learning outcomes that address the objectives (i.e., knowledge, communication, critical thinking, ethical research, etc.).

- Describe the methods of evaluation or assessment of student learning outcomes. (Include evidence for both direct and indirect methods.)

- Grading criteria (select from dropdown box); include a statement describing the criteria that will be used to assess students and how the final grade will be determined.

Criteria: Exams and Quizzes

- Identify the method(s) of instruction (select from dropdown box) and describe how the methods promote the likely success of the desired student learning outcomes.

Method of Instruction | Experiential |

C. Prerequisite(s):

- List prerequisite courses by subject abbreviation, number, and title.
- List other prerequisites and/or experiences/background required. If no prerequisites are indicated, provide an explanation for their absence.

D. Course Instructor(s):

- Provide the name, rank, and department/program affiliation of the instructor(s).
- Is the instructor currently a member of the Graduate Faculty? ✓ Yes — No
  (If the answer is no, indicate when it is expected that a request will be submitted.)

E. Course Outline:

- Provide an outline of topics to be covered and indicate the relative amount of time or emphasis devoted to each topic. If laboratory or field experiences are used to supplement a lecture course, explain the value of the experience(s) to enhance the quality of the course and student learning. For special topics courses, include a sample outline of a course that would be offered under the proposed course.

F. Reading List (including course text):

- A primary reading list or bibliography should be limited to material the students will be required to read in order to successfully complete the course. It should not be a compilation of general reference material.
- A secondary reading list or bibliography should include material students may use as background information.

G. Library Resources

- Describe the library resources that are currently available or the resources needed to support this proposed course.

H. Example of a Course Syllabus (While not a necessary component of this supporting document, an example of a course syllabus is available, for information, by clicking on the link below, which goes to the *Graduate School's Policies and Procedures Manual for Administering Graduate Student Programs*. See Appendix K.)
http://www.gradschool.purdue.edu/downloads/Graduate_School_Policies_and_Procedures_Manual.pdf

CE 51401

51401
CE ~~51400~~ - Building Controls

A. Justification for the Course:

The knowledge of automatic controls should be learned and applied for the senior undergraduate and graduate students in Architectural Engineering, so that they understand contemporary intelligent buildings, and they become ready to promote high performance buildings in their future professions.

Building control systems require multidisciplinary knowledge in electrical and electronic engineering, mechanical engineering, and building science. This course aims to convey the key concepts, methodologies, and technologies involved in building control systems for students, so they can have a solid and broad knowledge base to advance building control solutions for sustainable buildings.

This course also offers students with the skills necessary to assess indoor environment, to evaluate building control systems, and to integrate the operation of buildings in a productive, safe and efficient manner. The course was taught in Spring 2010 and Spring 2011 with enrollments of 15 and 20 students, respectively.

B. Learning Outcomes and Method of Evaluation or Assessment:

Course Learning Outcomes:

- Demonstrate basic HVAC processes and explain the function, layout, and operation of commercial HVAC systems
- Analyze the function, operating characteristics, and appropriate applications of basic control loops and control modes as found in direct digital, analog electronic, electric and pneumatic commercial control systems
- Understand and program a sequence of control, lay out a control system logic diagram and program it into a DDC controller
- Understand the function of network devices and network protocols such as a bridge, router, gateway, hub, firewall, Ethernet, TCP/IP, BacNet, and Lon Talk.
- Use general-purpose and specific building automation software to monitor and control a building HVAC system.
- Numerically model a building to define the key control parameters for thermal comfort.
- Develop and program alternative control algorithms for building HVAC systems in order to enable sustainable buildings.

CE 51401

Methods of Evaluation and Assessment

GRADING CRITERIA:

- Assignments- 25%
- Projects- 50%
- Presentation - 5%
- Quizzes- 20%

Unless otherwise specified, all assignments are due one week from the day assigned. Assignments are to be turned in at **the beginning** of the lecture on the **date due**. Late assignments will not be accepted. Put **your name, date due, problem number, course number** on everything you hand in.

COURSE ACTIVITIES:

- Assignments – there are three staged assignments to enhance students understanding of the course material. (calculations and written assignments).

- Project 1- students will assess indoor environmental quality for some spaces in the Black Cultural Center. They will require that you plan the spots to be measured on the floor plan. Students will collect and analyze data, and suggest the measures if it is needed to improve indoor environment quality of the studied spaces.

- Project 2 – students will document the interfacing components including sensors, actuators, controllers, and current control strategy used in the HVAC system for the Black Cultural Center. Students will be required to describe the HVAC control system for the building including hardware, software, and control sequences.

- Project 3 – students will explore alternatives to control the HVAC system for the Black Cultural Center to improve energy efficiency and indoor environmental quality. According to the control alternatives approved by Purdue Physical Facility engineers, students will implement new control alternatives in the control system and re-evaluate building energy consumption and indoor environmental quality. A comprehensive project report will be required to compare building performance by using the current control strategy and tested alternatives.

- Presentation – students will conduct a 15 minute presentation of Project 3.

- Quizzes – students will have two quizzes to test the understanding of course material

Method of instruction
Lecture

C. Prerequisite(s):

- **Restriction:** Senior status in the College of Engineering or Graduate-level standing.
- **Concurrent prerequisites:** CE 41300 Building Envelope Design and Thermal Loads, and CE 41400 Building Mechanical and Electrical System Design, or graduate standing

D. Course Instructor:

Dr. Ming Qu, Assistant Professor, School of Civil Engineering

Currently a member of the Graduate Faculty

E. Course outline:

Weeks 1-3: **Introduction to building controls, sensors, and indoor environmental quality (IAQ)**
Building function and controls; building indoor environmental quality analysis and diagnostics; gains and control action; temperature, humidity, pressure, flow rate sensors; and IAQ project. (3 weeks)

Weeks 4-5: **Controlled devices and various controls**
Actuators; self-powered and system-powered electric controls, pneumatic, analog and electronic controls; and IAQ project. (2 weeks)

Week 5.5: **HVAC system controls overview**
Sensors; various building HVAC systems; operation and controls of these systems. (0.5 week)

Weeks 6-8 **Control System Concepts**
PID control; Laplace transfer functions for building thermal control; system modeling; block diagrams; signal flow graphs. (3 weeks)

Weeks 9-11 **System Responses**
First-order system response; second-order system response; system responses and stability; and HVAC control system project.
(2.5 weeks)

Week 12 **Root Locus**
Root locus; and control system design by using root locus.
(1 week)

Weeks 13-15 **Introduction to Direct Digital Control (DDC) System and Z-transform**

DDC structure, hardware and software; DDC software (EIKON); Control logic and programming; demand control and new control algorithm; and control programming project. (3 weeks)

Week 16 **Quiz 2**
Final exam week

F. Reading List (including course text):
TBA – course textbook still under review.

G. Library Resources:
1. Nise, Norman S. 2004. Control Systems Engineering, Fourth Edition, Wiley
2. ASHRAE Handbooks - Fundamentals, 2009; HVAC Applications, 2007; HVAC Systems and Equipment, 2008, available on Knovel website: http://www.knovel.com/web/portal/main
3. Underwood, C.P. 1999. HVAC Control Systems: Modeling, Analysis, and Design. London: Taylor and Francis – Routledge
4. Levermore, G.J. 2000. Building Energy Management Systems: Application to Low-Energy HVAC and Natural Ventilation Control. London: Taylor and Francis.
5. Haines, R. W., and D.C. Hittle. 1993. Control Systems for Heating, Ventilating and Air Conditioning, Fifth Edition. New York: Chapman & Hall.

H. Sample Syllabus

CE 51401

Spring Semester 2011 **CE 59700 BUILDING CONTROLS**

LECTURES

MWF 2:30 p.m. – 3:20 p.m.
CIVL 2118

INSTRUCTOR

Ming Qu
Email: mqu@purdue.edu
Office: CIVL G243
Telephone: 494-9125

OFFICE HOURS

MW 3:30 p.m. – 5:00 p.m. and by appointment

PREREQUISITES:

Concurrent prerequisites: CE 41300 Building Envelope Design and Thermal Loads and CE 41400 Building Mechanical and Electrical System Design, or graduate standing.

COURSE OBJECTIVES: The goal of course is to offer students with foundational skills in areas of control engineering and building HVAC systems and skills to continue in expanding areas related to building automation and controls. The Course focuses on two primary objectives:

- An understanding of the theoretical and practical issues surrounding the building controls– problems encountered, state-of-the-art solutions; emphasis on interfacing components such as sensors and actuators to building control systems.

- In-depth study of building performance, operation, and controls – development of efficient operation and control strategies that improve building performance; implementation as digital control algorithms in building control systems through hands on projects.

GRADING:

Assignment - 25%
Projects- 50%
Presentation - 5%
Quizzes- 20%

CE 51401

COURSE POLICIES

- Class will start promptly on time – do not be late.
- Unless otherwise specified, all assignments are due one week from the day assigned. Assignments are to be turned in at **the beginning** of the lecture on the **date due**. Late assignments will not be accepted. Put **your name, date due, problem number, course number** on everything you hand in.

TOPICS AND TENTATIVE SCHEDULE:

- Introduction to building controls, sensors, and indoor environmental quality (IAQ): building function and controls; building indoor environmental quality analyses and diagnostics; gains and control action; temperature, humidity, pressure, flow rate sensors; and IAQ project. (3 week)
- Controlled devices: actuators; self- powered, system- powered, electric controls, pneumatic, analog and electronic controls; and IAQ project (2 week)
- HVAC system controls overview: sensors; various building HVAC systems; operation and controls of these systems (0.5 week)
- Control System Concepts: PID control; Laplace transfer functions for building thermal control; system modeling; block diagrams; signal flow graphs (2.5 week)
- System Responses: First-order system response; second-order system response; system responses and stability; and HVAC control system project (2 weeks)
- Root Locus: Root locus; and control system design by using root locus (1 week)
- Introduction to Direct Digital Control (DDC) System and Z-transform: DDC structure, hardware and software; DDC software (EIKON); Control logic and programming; demand control and new control algorithm; and control programming project. (3 weeks)

COURSE ACTIVITIES:

- Assignments – there are three staged assignments to enhance students understanding of the course material. (calculations and written assignments)
- Project 1- students will assess indoor environmental quality for some spaces in BLACK CULTURE CENTER. There will require that you plan the spots to be measured on the floor plan. Students will collect and analyze data, and suggest the measures if it is needed to improve indoor environment quality of the studied spaces.
- Project 2 – students will document the interfacing components including sensors, actuators, controllers, and current control strategy used in the HVAC system for BLACK CULTURE CENTER. Students will be required to describe the HVAC control system for the building including hardware, software, and control sequences.
- Project 3 – students will explore alternatives to control the HVAC system for BLACK CULTURE CENTER to improve energy efficiency and indoor environmental quality.

- According to the control alternatives approved by Purdue Physical Facility engineers, students will implement new control alternatives in the control system and re-evaluate building energy consumption and indoor environmental quality. A comprehensive project report will be required to compare building performance by using the current control strategy and tested alternatives.

- Presentation – students will conduct a 15 minute presentation of the project 3.
- Quizzes – students will have two quizzes to test the understanding of course material.

WEBSITE:
Purdue Blackboard - http://www.itap.purdue.edu/tlt/blackboard/

EMERGENCIES
In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances. Here are ways to get information about changes in this course. The course website: Blackboard, e-mail:mqu@purdue.edu.

ETHICS
Academic dishonesty will not be tolerated. Please refer to the section, "Definition of Academic Dishonesty," on the following web page: http://www.purdue.edu/odos/osrr/integrity.htm
Any incidents of academic dishonesty will, at the very least, result in zero credit for the associated assignment or exam. Further penalties, such as immediate failure of the course and/or referral to the Dean of Students, are at the discretion of the instructor.

CE 51401

TO: The Faculty of the College of Engineering

FROM: School of Civil Engineering of the College of Engineering

RE: New Graduate Course, CE ~~51400~~ 51401 Building Controls

The faculty of the School of Civil Engineering has approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

CE 51400 **Building Controls**
Sem. 1 or Sem. 2, Lecture 3, Cr. 3.
Restriction: Senior status in the College of Engineering or graduate-level standing.
Concurrent prerequisites: CE 41300 Building Envelope Design and Thermal Loads and CE 41400 Building Mechanical and Electrical System Design, or graduate-level standing.

Description: This course is designed to provide students with the knowledge of fundamentals, design, and analysis for building control systems. It primarily consists of three parts. The first part covers basic concepts, terminology, procedures and computations of control systems including block diagrams & transfer functions, open-loop & closed-loop control, control system modeling, time response, root locus techniques, design via root locus, and digital control systems. The second part focuses on issues surrounding the building controls: interfacing components such as sensors and actuators, problems encountered, and state-of-the-art solutions for building energy efficiency and thermal comfort. The third part aims to develop students' ability to convert control system concepts into real building control systems. The course provides a hands-on opportunity for students to complete three projects associated with the three primary components during the semester: indoor environmental quality assessment, HVAC system commissioning and its control analysis, and new control algorithm development for building energy efficiency, occupant health, and individual productivity.

Reason: The knowledge of automatic controls should be learned and applied for the senior undergraduate and graduate students in Architectural Engineering, so that they understand contemporary intelligent buildings, and they become ready to promote high performance buildings in their future professions. Building control systems require multidisciplinary knowledge in electrical and electronic engineering, mechanical engineering, and building science. This course aims to convey the key concepts, methodologies, and technologies involved in building control systems for students, so they can have a solid and broad knowledge base to advance building control solutions for sustainable buildings. This course also offers

APPROVED FOR THE FACULTY
OF THE SCHOOLS OF ENGINEER
BY THE ENGINEERING
CURRICULUM COMMITTEE
ECC Minutes #9
Date 1-17-2012
Chairman ECC R. Cipra

CE 51401

students with the skills necessary to assess indoor environment, to evaluate building control systems, and to integrate the operation of buildings in a productive, safe and efficient manner. The course was taught in Spring 2010 and Spring 2011 with enrollments of 15 and 20 students, respectively.

M.K. Banks
Bowen Engineering Head and Professor
Jack and Kay Hockema Professor of Civil Engineering