

COLLEGE OF ARTS & SCIENCES

STUDY ABROAD OFFICE

FedEx GLOBAL EDUCATION CENTER CAMPUS BOX **3130** CHAPEL HILL, NC **27599-3130**  T 919.962-7002 F 919.962-2262 studyabroad.unc.edu

August 29, 2018

Administrative Board of the College of Arts & Sciences

Dear Colleagues:

The Study Abroad Office and HonorCarolina submit for your approval a proposal for the establishment of a new program to be offered beginning **Summer 2019** and continuing annually.

Proposed Program: UNC Burch in Scotland (Design & Innovation in a Universal Healthcare System)

Proposed Program Location: Edinburgh, Scotland Faculty Program Leader: Kenneth Donnelly, Department of Biomedical Engineering

# **Program Information**

This proposed faculty-led program would be offered for **5+ weeks (6 credits)** during the **Summer** term.

Program Rationale: Healthcare provision is a fundamental cornerstone of a modern industrial nation. It is often said that economic productivity and access to healthcare are inextricably linked, but for an individual it is also key to a happier and longer lifespan. Innovation in medical technologies and treatment delivery has created a huge worldwide biomedical industry that is geared to treating many more medical conditions and providing care to more patients. This class will study the innovation in healthcare that arose in the early part of the 20th century in the United Kingdom which led to the establishment of the National Health Services in each of its constituent countries. The class will examine and discuss the geographic, demographic and political environment in the UK at the time of inception and will learn about the general population health improvements that resulted. Students will learn about the differences between each of the four health services which are run independently in Scotland, England, Wales and Northern Ireland but which appear to operate as one seamless organization to residents of the UK. The class will study how each health service has evolved since their creation to tackle the particular health issues experienced by their regions and how political and cultural differences have caused divergence between how the services are funded and delivered in each area. Comparisons with other alternative healthcare systems in Europe and the US will allow the class to examine different models of funding and delivery that exist and discuss how well they perform. The class will also survey the technologies and infrastructure that a future Scottish healthcare system might have access to and will be tasked with devising a future NHS Scotland which could exploit these for the benefit of the residents of Scotland and possibly act as a model for healthcare provision in other parts of the world. In the second section of the class, students will learn the inventive engineering design process through a project-based learning experience where they will design and prototype a healthcare-related device. Students will be guided through the creative processes that will allow them to develop critical thinking skills which will help them to identify



COLLEGE OF ARTS & SCIENCES

STUDY ABROAD OFFICE

FedEx GLOBAL EDUCATION CENTER CAMPUS BOX **3130** CHAPEL HILL, NC **27599-3130**  T 919.962-7002 F 919.962-2262 studyabroad.unc.edu

problems and opportunities which may not be obvious. They will learn how to identify stakeholders and their needs and use this to create a specification document which qualitatively and quantitatively identify the parameters that any solution must address. The class will use problem-based activities to demonstrate how the acquisition and application of knowledge from many diverse subject areas is the key to developing innovative solutions. It will look at case studies where innovation has been induced by chance discovery, exposure to existing solutions in other working contexts, and in casual discussions to show the many routes that creative thinkers can take when trying to problem solve. Through this, the students will learn that having an open mind and awareness of your surroundings is a key ingredient to creative thoughts and ideas. This class is ideal for teaching in Scotland. Scotland is one of the constituent nations of the United Kingdom and has considerable autonomy in many of its governmental responsibilities which includes healthcare provision. The NHS in Scotland has diverged in many areas from the other health services in the UK and, due to the funding mechanisms in place, has had to innovate to ensure increasing demands on its services can be met. Students will experience the culture of Scotland and learn how Scots view their place in the UK and the world. With the potential upheaval caused by the UK coming out of the EU, the future of the NHS is one of the major topics of discussion and its evolution may require further radical and innovative thinking.

**Target Audience:** The target audience would be students from any major who wish to study the process of design and innovation in the context of healthcare provision. The course will have two sections; one in which the evolution of a universal healthcare system - the National Health Service in Scotland - is studied and discussed; and the second in which the design process from problem identification to solution generation is taught in the form of a project-based learning experience. The first section will include topics that will discuss geographical, political, economic and demographic conditions that existed at the time of the establishment of NHS Scotland and how they compare to those which exist at present. The class will discuss how those conditions led to the structure of the health service and how the organisation has adapted to the changes since. The class will not require any previous expertise or technical knowledge but instead would benefit from having a broad range of views from students of any discipline. The second section of the class will study the process of design and innovation. This will include techniques used for root-cause analysis of problems, specification creation and functional decomposition. These are techniques that are applicable to any problem-solving situation and are extremely useful skills for any student to have. The class will also include training in makerspace technologies and will allow the students to gain experience in using these to create concepts and prototypes of ideas they may have related to their classes.

Other than BMME students, we believe this course would appeal to pre-med students ( a group we underserve and have often had to turn away from our Infectious Disease program), entrepreneurship and business students interested in healthcare, the Medicine, Literature, and Culture Minor students in Honors Carolina and those involved in the HHIVE. We will also market the experience to students interested in European Studies, and Public Policy with an emphasis on health (and Europe).

Anticipated Number of Students: 10 – 15 Student Levels Allowed: Sophomore, Junior, or Senior



COLLEGE OF ARTS & SCIENCES

STUDY ABROAD OFFICE

FedEx GLOBAL EDUCATION CENTER CAMPUS BOX **3130** CHAPEL HILL, NC **27599-3130**  T 919.962-7002 F 919.962-2262 studyabroad.unc.edu

**Program Learning Objectives:** The learning objectives for NHS Scotland's Policies, Problems and Innovative Solutions (section I of the course) are: Students will:

- Discuss the history of the NHS in Scotland in context with the geo-political, demographic and economic conditions that prevailed at its formation.
- Compare and contrast healthcare systems within the United Kingdom, other European countries and the United States
- Examine political influences on healthcare systems and how policies can encourage or stifle innovation within them
- Predict the influence of technology on the future healthcare system requirements
- Apply design principles to developing solutions which may address some of the issues NHS Scotland faces with healthcare delivery

For section II, Innovation and Design for Healthcare Technologies: Students will learn to:

- Demonstrate critical thinking skills to solve problems
- Identify problem needs and formulate solutions
- Competently use Computer Aided Design software, to design a system, component, or process to meet desired needs in healthcare.
- Understand the concepts of prototyping to design and manufacture a system
- Be familiar with the tools and fabrication processes required to build prototypes
- Work on a project within a group environment. Manage the project goals through meeting deadlines, keeping proper documentation and teamwork
- Communicate their project progress through technical presentations sessions

## **Program Academics**

**Proposed Course Name/Number:** Proposed BMME 290: Special Topics on Biomedical Engineering (section 1: 3 credits; section 2: 3 credits)

**Course Description:** The BMME290 Section I class will study the evolution of the National Health Service in Scotland and will enable students to appreciate how design and innovation should not just be thought of in terms of technology and devices but also in terms of ideas, policy and organizational structure. They will examine how historical, political and economic conditions can provide the impetus for innovation and, conversely, how constraints created by government inertia, funding sources and cultural conservatism can slow this process. This class will primarily take place in the mornings during the semester and will cover topics which are of relevance to the creation and evolution of NHS Scotland such as:

- The demographics and geography of Scotland
- Post-war politics and reconstruction
- Economic changes in the UK
- Perceptions of the NHS from population to government
- Differences in Healthcare provision within the UK
- Comparison with worldwide public and privately-funded healthcare systems
- Future political economic challenges such as Brexit This class will also survey the emerging technologies which could become available to healthcare providers and which could



COLLEGE OF ARTS & SCIENCES

STUDY ABROAD OFFICE

FedEx GLOBAL EDUCATION CENTER CAMPUS BOX **3130** CHAPEL HILL, NC **27599-3130**  T 919.962-7002 F 919.962-2262 studyabroad.unc.edu

revolutionize how it is delivered. It will ask students to think how these and other technologies which improve the life-span of the population may introduce new funding and capacity problems for a fully publicly-funded healthcare system.

The BMME290 Section II class is an approved substitute for BMME 210, a core design class in the Biomedical and Health Sciences Engineering undergraduate curriculum. This class will be taught as a project-based learning course which will allow students to learn the design process by designing and building a prototype solution to a healthcare-related problem. This may be a medical device, a problem experienced by a patient, clinician or administrator, or it may involve the design of an area of medical infrastructure. Through this problem, the students will learn the process of problem solving and creative design. In developing their projects, the students will gain experience in prototyping technologies such as 3D modelling software, laser cutters and 3D printers. The students will also learn how to use some simple electronics and microcomputers to control the environment and make things move. In doing so, it is hoped that the students taking the class will leave with a confidence that they can realize their own ideas without requiring costly engineering infrastructure. This is the philosophy of the maker-movement, and this is a golden age of making where previously prohibitively expensive technologies are accessible to hobbyists, inventors and designers allowing them to innovate new ways to improve people's lives. The Internet of Things, where devices have built-in internet connectivity is also at an embryonic state and in many cases has been used for applications where it is completely superfluous. Giving future innovators an understanding of how these technologies can be best used is another aim of the course so that they are aware of them and appreciate that 'smart' technologies are not always clever solutions to problems.

**Description of Academic Instruction:** Much of the class for the BMME290 section I class will be taught in the classroom using lectures and discussions. There will be several field trips including to the Scottish Parliament where it is expected students will be able to interact with politicians and government administrators. For BMME290 section II, classroom instruction will be in the form of lecture and group-based project learning activities. These will be supplemented by hands-on activities in the local Makerspace facilities enabling students to learn some design and manufacturing hands-on skills.

**Description of Excursions/Activities:** There will be a number of excursions. The first will be a day trip to Dundee where students will visit the new Victoria and Albert Museum. This museum is the only one in Scotland which focuses on art and design. The exhibits here cover many aspects of international design but also a section showing Scotland's industrial design heritage and its influence on the world. The second part of the trip to Dundee will be to visit one of two labs which are providing world-leading research and innovation in healthcare related fields. Students will interact with members of these labs and be able to discuss their approaches in using new techniques and technologies to advances their fields. A second excursion will be to the Scottish Parliament. Students will be able to engage with politicians from all parties and question them regarding their view of the problems currently experienced by NHS Scotland and their policies on solving them. Students will gain an appreciation of how political influence on healthcare provision can be the revolution that causes new innovation but also can cause governments to be more risk-averse and cause stagnation. The third excursion will be to the new Queen Elizabeth University Hospital in Glasgow. Students will



COLLEGE OF ARTS & SCIENCES

STUDY ABROAD OFFICE

FedEx GLOBAL EDUCATION CENTER CAMPUS BOX **3130** CHAPEL HILL, NC **27599-3130**  т 919.962-7002 F 919.962-2262 studyabroad.unc.edu ) patients to gain the

be given the opportunity to speak to clinicians, administrators and (hopefully) patients to gain their perspective on healthcare delivery in Scotland. The final excursion will be to the Roslin Institute near Edinburgh. This is the birthplace of Dolly the Sheep, the first cloned mammal. Students will interact with lab members at the institute and learn their perspective of the future technologies that may evolve from their research. They will also be able to discuss how moral and regulatory objections may limit the application of new innovations and how these must be considered.

#### Course Prerequisites: NO

**Degree Requirements?** This proposed course will fulfill BMME290 Section I - Elective course BMME290 Section II - Major-required course meeting the core design requirements of the BME major normally covered by BMM210

#### Language Prerequisites: NO

A proposed syllabus is included as an addendum to this proposal.

### **Faculty Program Leader Information**

**Faculty Program Leader Bio:** I am a faculty member in the Department of Biomedical Engineering at UNC. I teach the sophomore and junior level classes in biomedical engineering design and have previously taught the level design classes and the course in medical instrumentation. Prior to arriving in Chapel Hill, I was a faculty member at the University of Dundee in Scotland where I was a researcher in regenerative medicine and a lecturer on the Mechanical Engineering and Innovative Product Design undergraduate programs.

I have experience in using 3D computer-aided design technologies and in using rapid manufacturing and prototyping technologies for concept and product development. My background in electronics and microcontroller systems enables me to develop circuits and software for smart technologies which I use for biomedical research systems.

I have a longstanding interest in the use of design and technology for healthcare applications and have been part of projects which have investigated infrastructure-related design problems in healthcare environments. This provoked an interest in studying health improvements that may result from applying design principles to organisational structure to resolve problems in funding and delivery in healthcare systems.

**Experience in Proposed Location(s):** I am a native of Scotland so I know Edinburgh extremely well. I also have many academic contacts in the University of Edinburgh. My last visit was in 2014.

**Experience Leading Student Groups:** I do not have experience of leading longer term programs with students. However I have led many field trips for students in visiting industrial and research lab locations outside of the classroom in the UK and the US.



COLLEGE OF ARTS & SCIENCES

STUDY ABROAD OFFICE

FedEx GLOBAL EDUCATION CENTER CAMPUS BOX **3130** CHAPEL HILL, NC **27599-3130**  T 919.962-7002 F 919.962-2262 studyabroad.unc.edu

# Program Location(s)

**Proposed Location(s):** The class will primarily be taught in Edinburgh, the capital of Scotland. There will be excursions to two other cities in Scotland - Glasgow and Dundee.

**Location Rationale:** Edinburgh has been chosen as it is the capital of Scotland and has excellent transport links to the rest of the UK, Europe and to the US. Edinburgh houses the Scottish Parliament and the main administrative offices of NHS Scotland and so attracts a visitors and residents from many other parts the world who work with or in these organisations. Students will find Edinburgh to be a very friendly city and will be able to easily interact with the local inhabitants which will provide for an excellent cultural exchange of views. Edinburgh grew from a medieval city, a large part of which still exists and has many interesting historic and cultural attractions for students to visit. It has excellent rail links to other cities in Scotland and also to the more remote areas such as the Highlands.

The course will bring in policy experts, administrators, and policy maker in Scotland. I have already reached out to a number of organisations including the Scottish Government and the NHS administration to enquire about visits to the Scottish Parliaments, meetings with political party representatives who have a responsibility for health and guest lectures from NHS administrators. I am still waiting to hear back from most of them but will prod a bit harder once the semester here gets a bit more stable. Additionally, the students will conduct site visits to organizations and institutions that reflect the innovations discussed. Additionally, the students will be making use of the University of Edinburgh's makerspaces and design resources to address a design problem in teams, with the hope of collaborating with local students on the teams as well. These collaborations and input from local sources outline the experiential opportunities and the reason the course would be located in Scotland.

**Connections at the Proposed Location:** UNC has a partnership with the University of Edinburgh which we will use to gain access to classroom space, makerspace facilities and student housing.

When Professor Donnelly was in Scotland over the summer he met with contacts from Edinburgh, Glasgow and Dundee Universities and they were very supportive of the class and have offered assistance with making connections to local NHS administrators and clinicians; research institutes and NHS spin-out companies to enable visits and talks with the students. The contacts he met with are Professor Robert Keatch at Dundee University who has extensive connections with NHS Tayside and Ninewells Hospital; Dr Philip Hands from the School of Engineering at Edinburgh University and Dr Henrik Gollee from the Biomedical Engineering department at the University of Glasgow.

# **Health & Safety Information**

**Health Insurance:** The Study Abroad Office coordinates with the Office of Risk Management Services to enroll student and faculty participants in international accident and health insurance through GeoBlue for the duration of the program.



COLLEGE OF ARTS & SCIENCES

STUDY ABROAD OFFICE

FedEx GLOBAL EDUCATION CENTER CAMPUS BOX **3130** CHAPEL HILL, NC **27599-3130**  T 919.962-7002 F 919.962-2262 studyabroad.unc.edu

**Safety & Risk Information:** Edinburgh as part of the UK has a level 2 travel advisory from the State Department warning of the potential of terrorist attacks. Crime can also be an issue as with any large city. Scotland has some issues with alcohol-induced violence and has a lower drinking age than the US so students are advised to be aware of their surroundings at all times but especially later at night when nightclubs and pubs are closing.

Study Abroad Office staff will continue to monitor events in the host country and the U.S. State Department Travel Advisories in accordance with the UNC *Policy Concerning Global Study, Travel, and Research*.

**Health Information:** There are no travel health notices for travel to Scotland. Students may be passing through an English airport on their way to Edinburgh and there is a current health notice for measles in England. Students should ensure they are vaccinated for this.

**Required Vaccinations (if applicable):** The CDC recommendations are: Make sure you are up-todate on routine vaccines before every trip. These vaccines include measles-mumps-rubella (MMR) vaccine, diphtheria-tetanus-pertussis vaccine, varicella (chickenpox) vaccine, polio vaccine, and your yearly flu shot.

Health, safety, and security information will be presented to students during the required predeparture orientation.

# Conclusion

A letter of support from the home academic department is included in as an addendum to this proposal.

We are happy to provide any additional information necessary for your review of this program. Thank you for your time and your support of global opportunities for Carolina students.

Sincerely,

ason Kinnear

Jason A. Kinnear Interim Associate Dean of Study Abroad

Dear Study Abroad Program Evaluators:

It is with pleasure that I recommend Dr. Kenneth Donnelly as a faculty director of the study abroad program, Design and Innovation in NHS Scotland. As a native of Scotland who was educated and worked professionally for 12 years in Scotland, Dr. Donnelly is naturally familiar with the history and culture of Scotland and has the professional collaborations necessary to implement a meaningful study abroad experience.

The study abroad experience will include a 3-credit hour design course. For students in Biomedical and Health Sciences Engineering, the course will meet the requirement for sophomore engineering design. For other students, we will seek approval for the course to meet the requirements of a Physical Sciences course without lab.

The 2nd component of the course is a 3-credit hour course examining the interaction between politics, national health care and scientific innovation. We will seek approval for the course to meet the requirements of the Global Issues Connections requirement. All students will receive credit for experiential education.

Study abroad experience for students is a high priority for our department, but it is difficult for engineering students to participate in fall or spring semester study abroad programs due to the highly structured curriculum requirements of an engineering degree. Summer programs are ideal, but our program is not large enough to support a summer study abroad experience targeted solely to our students. Dr. Donnelly's solution was to design an inclusive study abroad experience. This will give non-engineering students the opportunity to conduct a formal needs-based design process, a curriculum normally limited to engineering students due to resource and expertise limitations, while giving all students interested in careers in health professions the opportunity to study medicine in the broader context of medical delivery changes and development through innovation as well as the political and social pressures that impact health services.

Dr. Donnelly has 15 years experience teaching engineering design both at UNC and at the University of Dundee in Scotland. His engineering skills include skills in electronic engineering, mechanical design and manufacturing, a much more diverse set of skills than a typical engineer. He has a unique ability to develop meaningful design projects that fully engage and challenge students. For example, previous design projects for sophomore design, the class proposed for the study abroad experience, include a remotely driven scale model of a transforming wheel chair, and, more recently, physical models of biological components donated to Feelin' DNA, an organization that uses 3D models to teach STEM topics to visually impaired students.

Kenny is a gentle soul who motivates students without intimidating them. I feel the personal connection with the instructor must be important for a successful study abroad experience, and Kenny easily earns the trust and respect of our students on friendly terms. His teaching evaluations are excellent.

I'm excited at the prospect of the Design and Innovation in NHS Scotland study abroad program and its benefits for UNC students and highly recommend Dr. Kenneth Donnelly as director of the program.

Sincerely,

Lianne A. Cartee, Ph.D.

#### **SYLLABUS**

#### I. ACADEMICS

This course will be two 3-credit hour classes of 5-week duration. Students taking the class will be enrolled in the following academic courses:

- BMME 2xx: Special Topics on Biomedical Engineering (NHS Scotland Policies, Problems and Innovative Solutions)
- BMME 2xx: Special Topics on Biomedical Engineering (Innovation and Design for Healthcare Technologies)

The BMME2xx Section I class will study the evolution of the National Health Service in Scotland and will enable students to appreciate how design and innovation should not just be thought of in terms of technology and devices but also in terms of ideas, policy and organizational structure. They will examine how historical, political and economic conditions can provide the impetus for innovation and, conversely, how constraints created by government inertia, funding sources and cultural conservatism can slow this process. This class will primarily take place in the mornings during the semester and will cover topics which are of relevance to the creation and evolution of NHS Scotland such as:

- > The demographics and geography of Scotland
- Post-war politics and reconstruction
- Economic changes in the UK
- > Perceptions of the NHS from population to government
- > Differences in Healthcare provision within the UK
- Comparison with worldwide public and privately-funded healthcare systems
- Future political economic challenges such as Brexit

This class will also survey the emerging technologies which could become available to healthcare providers and which could revolutionize how it is delivered. It will ask students to think how these and other technologies which improve the life-span of the population may introduce new funding and capacity problems for a fully publicly-funded healthcare system.

The BMME2xx Section II class is an approved substitute for BMME 210, a core design class in the Biomedical and Health Sciences Engineering undergraduate curriculum. This class will be taught as a project-based learning course which will allow students to learn the design process by designing and building a prototype solution to a healthcare-related problem. This may be a medical device, a problem experienced by a patient, clinician or administrator, or it may involve the design of an area of medical infrastructure. Through this problem, the students will learn the process of problem solving and creative design. In developing their projects, the students will gain experience in prototyping technologies such as 3D modelling software, laser cutters and 3D printers. The students will also learn how to use some simple electronics and microcomputers to control the environment and make things move. In doing so, it is hoped that the students taking the class will leave with a confidence that they can realize their own ideas without requiring costly engineering infrastructure. This is the philosophy of the maker-movement, and this is a golden age of making where previously prohibitively expensive technologies are accessible to

hobbyists, inventors and designers allowing them to innovate new ways to improve people's lives. The Internet of Things, where devices have built-in internet connectivity is also at an embryonic state and in many cases has been used for applications where it is completely superfluous. Giving future innovators an understanding of how these technologies can be best used is another aim of the course so that they are aware of them and appreciate that 'smart' technologies are not always clever solutions to problems.

The course will enable students to experience the Scottish culture and get a better understanding of how their worldview is shaped by environment and surroundings. It will ask whether the reputation for Scottish innovation and engineering is justified in the modern age or whether it was a product of a different time and is now purely marketing hype. It will assess the mood of the population in taking high risk decisions, such as that which led to the creation of the NHS, and whether the decisions made on their behalf can be as innovative in meeting their future healthcare needs.

If approved, the class will satisfy a core Biomedical Engineering requirement and a special topics elective. The class will not require any language skills other than English, no prior technical knowledge or background will be necessary; however, students will be expected to fully engage with all aspects of the course. The course will be marketed to students of any major at UNC and will enable them to participate in activities which develop skills in critical thinking, creative and inventive approaches to problem solving and communication with wider audiences. The course will provide a perfect opportunity for Biomedical Engineering students to gain a study abroad experience whilst still satisfying core elements of their curriculum. Students of other science and healthcare-related majors will also benefit from learning about the research undertaken in other parts of the world which lead to new technologies which can be used in medical applications.

#### Key Readings:

"A Country Doctor" by A J Cronin "The Citadel" by A J Cronin Report of the Highlands and Islands Medical Service Committee (Dewar Report) Selected excerpts from "The National Health Service in Scotland: Origins and Ideals, 1900-1950" by Morrice McCrae "The four healthcare systems of the United Kingdom: how do they compare" – Nuffield Foundation report

Selected readings from "How the Scots Invented the Modern World" by Arthur Herman Excerpts from "Product Design and Development 6<sup>th</sup> edition" by Steven Eppinger, Karl Ulrich "Biodesign: the process of innovating medical technologies" by York et al "The Art of Invention" by Steven J Paley "How to think like Leonardo da Vinci" by Michael J Gelb

Requirements: BMME2xx Section I

#### Learning Objectives

Students will:

- Discuss the history of the NHS in Scotland in context with the geo-political, demographic and economic conditions that prevailed at its formation.
- Compare and contrast healthcare systems within the United Kingdom, other European countries and the United States
- Examine political influences on healthcare systems and how policies can encourage or stifle innovation within them
- Predict the influence of technology on the future healthcare system requirements
- Apply design principles to developing solutions which may address some of the issues NHS Scotland faces with healthcare delivery

Tested by Quizzes, weekly tests, research and discussion papers

#### BMME2xx Section II

Learning Objectives

Students will learn to:

- Demonstrate critical thinking skills to solve problems
- Identify problem needs and formulate solutions
- Competently use Computer Aided Design software, to design a system, component, or process to meet desired needs in healthcare.
- Understand the concepts of prototyping to design and manufacture a system
- Be familiar with the tools and fabrication processes required to build prototypes
- Work on a project within a group environment. Manage the project goals through meeting deadlines, keeping proper documentation and teamwork
- Communicate their project progress through technical presentations sessions

Tested by: CAD skill assignments, project assignments, design review and final project presentations

## BMME2xx Section I

Quizzes (10% of final grade) -4-5 questions on reading material for the class session which students will be required to answer at the start of class.

**Discussion Papers (40% of final grade)** – discussion of a specific topic related to innovation and the NHS in Scotland.

Class exams (30% of final grade) – 1-hour exams which will test how well students can apply the skills and knowledge learned in each phase of the class to different applications.

**Final Project Paper (20% of final grade)** – students will present their ideas of how a future NHS Scotland could be structured to accommodate demographic changes and to take advantage of evolving technologies.

## **BMME2xx Section II**

**Solidworks CAD Assignments (40% of final grade)** – Students will submit Solidworks documents demonstrating their skills using certain CAD techniques.

**Project assignments (20% of final grade)** – These will be exercises undertaken by students as part of the mini-projects in each phase of the project. These will be written exercises such as

creating a specification document, or they may ruse of Solidworks to design a part or parts which could be used for the project. These assignments may be part of class activities or homework. **Presentations (30% of final grade)** – there will be two opportunities for students to practice project presentation skills

**Peer Review** (10% of Final grade) – The project in this section will be undertaken by teams of 3 or 4 students. Each student will be given the opportunity to give a contribution to the final grade of their team members based on their project efforts.

#### **III. Program Travel**

Edinburgh, the capital of Scotland, is the intended primary location for the class. UNC has a partnership agreement with the University of Edinburgh and we will be able to access accommodation, classroom and makerspace facilities through them. Edinburgh is an ideal location as it has many local amenities and activities for students to experience in their downtime. It also has excellent transport links through rail and air to the rest of Scotland, the UK and Europe.

The University of Edinburgh, one of the oldest in the UK, has a history of world-leading research and innovation. It is ranked fourth in the UK for research excellence and is rated in the top 50 for universities worldwide. The university has graduated alumni who have historically contributed to many vital discoveries and inventions in the healthcare field including early anesthetics, identification of the SARS virus and developing new post-stroke rehabilitation procedures and policies which improve recovery. The university has a combined College of Medicine and Veterinary Medicine which allows for cross-pollination of ideas and discoveries to enable relevant developments in the human medical domain to be translatable to the animal medical field and vice-versa. One major area where this collaboration has produced world-leading research is in embryonic cloning, with the university, through its Roslin Institute, producing Dolly the Sheep, the world's first cloned mammal. Edinburgh University also hosts three interdisciplinary research centres which study relevant topics related to the class. These centres are the Centre for Global Health Research, the Centre for Medical Informatics and the Centre for Population Health Sciences. It is anticipated that the class will interact with researchers in these centres to better understand how their research can translate into innovations in healthcare which become more universally accessible worldwide.

The class will visit other parts have Scotland that are relevant to the course structure. One of the planned visits is to the city of Dundee. This visit will be split into two halves. The morning session will be to visit the new V&A Museum, which is opening in the fall of 2018. This museum is a partner of the internationally renowned Victoria and Albert Museum and is the first in Scotland to focus on design topics and the graphic arts. From the design of the museum itself to the international and Scottish design galleries, the class will gain an insight into the influences that shape creative product output. The second session of the trip will be to visit one of two world-class medical research centres at the University of Dundee. The first option is the Centre for Anatomy and Human Identification (CAHID). This centre has international expertise in investigating and studying human remains and providing forensic expertise to law enforcement agencies throughout the world. It is also at the forefront of developing and adopting new technologies which allow detailed analysis of bone tissue and in the reconstruction of facial

features. The centre is also highly experienced in multimedia dissemination of their work; their research in recreating historical narratives from human remains has been the subject of several television series by the BBC. The second option is the Institute for Medical Science and Technology located at Ninewells Hospital in the city. This centre is at the forefront of innovation in medical imaging and keyhole surgery technologies: investigating how the two can be combined to enhance image-guided surgery techniques. Visits to either of these centres would give the class a valuable insight into how innovation is not just based on new devices but also in the adaptation and repurposing of existing technologies to new environments.

A visit to a modern hospital would give students an experience of what it is like to be at the front-line of healthcare delivery in the NHS. It is planned that the class will visit the new Queen Elizabeth University Hospital in Glasgow, Scotland's largest city. With this visit, students would meet with hospital administrators along with clinicians and patients so that they can hear the experiences from each of these stakeholders and gain a greater understanding of what problems each experience and how they could potentially be addressed.

Another possible planned visit would be to the global headquarters of Touch Bionics which based in Livingston near Edinburgh. This company originated as a spin-out from the Scottish NHS and leads the world in developing advanced upper body prosthetic limbs including the I-Limb – the world's first electromechanically actuated hand with fully articulating fingers. It is expected that this visit will enable the class to experience the technologies and ideas that exist at the forefront of this field of medical devices and allow them to explore how these ideas might be implemented at a lower cost level.

# V. Program Itinerary and Class Schedule

#### Week 1

Day 1:	Morning:	Program overview Class discussion and Q&A (resources:	2 hours
		lecture with projection)	1 hour
	Afternoon	<i>Invention and innovation, design and manufacturing.</i> The merging of knowledge and creativity. (resources: lecture with projection)	1 hour
		Set up Solidworks CAD software and work on parts & assembly tutorials (resources: Solidworks software, student laptops).	1 hour
Day 2:	Morning:	<b>The Highlands and Islands Medical Service.</b> Lecture and discussion session about the demographic and geographic difficulties involved in delivering primary healthcare in rural Scotland which led to the formation of HIMS. (resources: lecture with projection, copies of Dewar Report, excerpts from "A Country Doctor" and "The Citadel", whiteboard, student laptops)	2 hours
	Afternoon	<b>Problem or opportunity?</b> Lecture, workshop & discussion with case studies on how problems can be redefined to identify the real underlying issues and how sometimes problems become opportunities. (resources: lecture with projection)	2 hours
Day 3:	Morning:	<i>The road to Universal Healthcare</i> . Lecture and discussion about the formation of the National Health Services in the UK. (resources: lecture and video clips with projection, copies of Beveridge Report, whiteboard, student laptops)	2 hours
	Afternoon	Serendipity, observation and repurposing – the art of invention. Workshop, discussion and quiz with case studies. (resources: case studies handout, worksheet, written quiz, student	2 hours
Day 4:	Morning:	Visit V & A museum in Dundee to see the exhibits on the history of engineering and design in Scotland. We will consider how history, environment and culture shape the creative output of a nation. (resources: student notebooks)	2 hours
	Afternoon	Visit to either IMSAT or Centre for Anatomy and Human Identification at University of Dundee. (resources: student notebooks)	2 hours

Day 5:	Morning:	<i>NHS in the sixties – the glory years?</i> Discussion about the performance of the NHS in the 1960s when it is widely perceived that performance and funding were at their highest. Is this erroneous? If not, what can we learn from that period? (resources: lecture with projection)	2 hours
	Afternoon	Free Time	
Week 2			
Day 1	Morning:	What did the NHS ever do for us? Workshop & discussion with case studies. Contributions from the NHS to global healthcare technologies. (resources: case studies handout, worksheet, written quiz, student notebooks)	2 hours
	Afternoon	<b>Defining a problem</b> – how we can qualitatively and quantitatively create the boundaries which we need our solution to address.	1 hours
		Workshop - Create a problem specification document – Treatment Delivery system (TDS) (resources: lecture with projection, worksheets, whiteboard)	1 hours
Day 2:	Morning:	<b>Under pressure – the 1970's and 1980's</b> – lecture and class discussion on the most turbulent time in the NHS. Labour strikes and economic downturn caused major pressures for the NHS. Did the government fall out of love with a public healthcare system? Did the population? (resources: lecture with projection)	2 hours
	Afternoon	<i>Functional decomposition -</i> breaking big problems into little ones. (resources: lecture with projection)	1 hour
		Workshop – 3-level functional decomposition of Treatment delivery system (2hours) (resources: lecture with projection, worksheets, whiteboard)	2 hours

Day 3	Morning:	Class exam	$1 \; { m hour}$
		<b>NHS the role of the universities</b> – lecture and discussion about how the publically funded Scottish universities interact with the NHS in training, research and funding. Is this a perfect marriage? (resources: lecture with projection)	2 hours
	Afternoon	<b>Solidworks workshop</b> – surfaces, sweeps, revolves and fillets(resources: lecture with projection, worksheets, whiteboard)	3 hours
Day 4:	All Day:	<i>Visit to Scottish Parliament</i> – meet with Scottish government and opposition MSPs to discuss the present- day challenges facing NHS Scotland. (resources: student notebooks)	5 hours
Day 5:	All Day:	Free Time	
Week 3			
Day 1:	Morning:	The United Kingdom - Four nations united yet divided by healthcare. Class discussion on the Nuffield report into the 4 UK health services. What can each organisation learn from the others? Are they reactive, innovative or inertial. (resources: lecture with projection, copies of Nuffield Report, student laptops, student notebooks)	2 hours
	Afternoon	<i>Ideation processes</i> . Ideation exercise for TDS solutions based on specification and functional decomposition. (resources: whiteboard, student notebooks)	3 hours
Day 2:	All day:	<b>Travel to Glasgow to visit Queen Elizabeth University Hospital</b> . Meet with clinicians, patients and administrators of Scotland's newest NHS hospital. Discuss the challenges each of them faces. (resources: student notebooks)	5 hours
Day 3	Morning:	<b>NHS and EU</b> - Class discussion on how other EU nations provide their healthcare systems. Could a different model taken from one of these nations work better for NHS Scotland or could a hybrid model take the best parts from each. (resources: lecture with projection, copies of Nuffield Report, student laptops, student notebooks)	2 hours
	Afternoon	<b>Concept Generation and selection</b> – lecture on what makes a good concept model and how designer bias can be eliminated when selecting team concept designs.	1 hour
		Solidworks workshop – Assemblies and Model-based Definition	2 hours

Day 4:	Morning:	Class exam	$1 \ { m hour}$
		<b>NHS and US</b> - class discussion on the difference between fully public and fully private healthcare systems. Could either system work as well or better in each nation? What are the cultural roadblocks to change? (resources: lecture with projection, worksheets, whiteboard)	2 hours
	Afternoon	<i>Feeding the information machine</i> – lecture on how documentation helps to formulate ideas and enable future innovation and dissemination. Lessons from Da Vinci's lost	1 hour
		designs. (resources: lecture with projection, whiteboard)	2 hours
		Solidworks workshop Motion studies and simulation (resources: lecture with projection, student laptops with Solidworks installed)	
Day 5:	All day:	Free time	

Week 4			
Day 1:	Morning:	NHS – Public / Private Partnership or Profit before Patient? A look at how infrastructure funding problems were addressed by using a model where private companies were used to build and run healthcare facilities which provided NHS treatment. What was the outcome from that experiment?	2 hours
	Afternoon	Motors and Mechanisms – lecture on how mechanical motion can be harnessed and used for medical technologies?	1 hour
		Workshop on driving motors with microcontrollers and project work	2 hours
Day 2:	All day:	<i>Makerspace time</i> – lectures and instruction on 3D printing and laser cutting. Mini tutorials on assembly techniques and the proper use of hand tools. (5 hours) (resources: 3D printers, laser cutter hand tools)	5 hours
Day 3	Morning:	<b>NHS Brexit challenges</b> – lecture and discussion on the problems that NHS Scotland might experience when the UK exits from the EU. With large numbers of EU workers in the NHS will there be enough staff? How will cross-border treatment be affected? Will the economy sustain a publicly funded health service?	2 hours
	Afternoon	Design Review – students will present their concept ideas for their project. Instructors and class members will critique and provide positive feedback to each team	2 hours
Day 4:	Morning:	21 <sup>st</sup> Century Docs – how can healthcare be transformed to meet the needs of the 21 <sup>st</sup> century population. Will clinicians become engineers? (resources: lecture with projection, case study handouts, worksheets)	2 hours
	Afternoon	Smart Smart or Dumb Smart – how we can make technology think, where it is best used and why smartness is sometimes a dumb idea. (resources: lecture with projection, case study handouts & worksheets)	1 hour
		Arduino workshop – learn how to use a microcontroller to control our environment	3 hours
Day 5:	Morning:	<i>Future NHS – Robots, telepresence and AI.</i> Will the future surgeons need to be in the same location as a patient or can we bring complex surgery to remote locations? (resources: lecture with projection, handouts and worksheets, quiz)	2 hours

Afternoon Free time

Week 5			
Day 1:	All day:	Visit to Roslin Institute – cloning technologies and tissue engineering (resources: student notebooks)	3 hours
Day 2:	Morning::	<b>I-Robot to I-Robert</b> ; can prosthetics and implants give us superpowers. Lecture and discussion on how future technologies could be used to create half-human, half- cyborg. (3 hours) (resources: lecture with projection, handouts and worksheets)	2 hours
	Afternoon	Project work	3 hours
Day 3	Morning:	<b>Designer drugs</b> – can pharmaceuticals and mathematics give us the personal treatment? (resources: lecture with projection, case study handouts, worksheet)	2 hours
	Afternoon	<b>Testing, testing</b> – Lecture on strategising product testing. Lessons from prototyping to improve design for manufacturing through to gaining regulatory approval (resources: lecture with projection, case studies handouts and worksheet)	1 hour
		Project work	2 hours
Day 4:	Morning:	<b>An aging population</b> . How much can we extend our lifespan through medical technology and lifestyle changes? What will that mean for demographics and healthcare costs? (resources: lecture with projection)	1 hour
	Afternoon	Project Presentations and discussion (resources: lecture with projection, student laptops)	2 hours
Day 5:	Morning:	Class exam	1 hour
		Program Review and discussion (resources: lecture with projection, student notebooks, quiz)	2 hours

Afternoon Free time