UNIVERSITY OF GLOUCESTERSHIRE
at Cheltenham and Gloucester

PROJECT APPROVAL

This form should be completed by every candidate and submitted for approval to the School PGR Lead. Please refer to the Research Student Handbook and the Academic Regulations for Research Degrees Provision for further detailed information.

SECTION 1: STUDENT TO COMPLETE			
Family Name	Rhodes	**First Name**	Mark
Student number	S1211024	**Mode of Study**	Full-time

RESEARCH DEGREE PROJECT: **Doctor of Philosophy (PhD)**

COLLABORATING ESTABLISHMENT (A collaborating establishment is an organisation that enters into a formal written agreement with the University to provide facilities and other resources, e.g. access to a database, library, archive etc. A letter of support from the collaborating establishment confirming any agreed arrangements must accompany this application).

Dalton Cumbrian Facility (DCF)

1. Arduino Radiation Tolerance Investigation – **Letter Received** (Dr Ruth Edge).

TITLE OF YOUR RESEARCH PROJECT

The Internet of Things (IoT), Environmental and Radiation monitoring of the abandoned city of Pripyat.

PROPOSED PLAN OF WORK

The total word count for this section, a) to d), is a **maximum of 1,500 words**, excluding bibliography.
All plans should address the required headings set out below

a) AIM OF THE RESEARCH

(Briefly state the main purpose(s) of the research and comment on its wider significance)

The aim of this research is to design, build and develop a new method of monitoring the levels of radiation and environmental factors within the abandoned city of Pripyat using the Internet of Things (IoT) capturing and storing this data within a MySQL database for future analysis.

I will use Pripyat as the main testing ground as it is a perfect location to test the environment and how it effects the levels of radiation within the city.

b) RESEARCH OBJECTIVES

(These must be highly focused and feasible)

RQ1: Tx/Rx Module Range Investigation.

RO1: Acquire a variety of Tx/Rx modules for the Arduino platform.

R02: Test the range/distance of communication for each module type over a variety of terrains and environments.

R03: Investigate if bad weather influences the total range of the Tx/Rx modules.

RQ2: How long can Microprocessors operate when subjected to a concentrated source of radiation?

RO1: Irradiate several Arduinos Uno's [1] with a concentrated source of Cobalt 60 (^{60}Co) at the Dalton Cumbrian Facility [2].

RO2: Investigate suitable materials that can prolong the life of the Arduino during irradiation.

RQ3: How long can the Arduino platform operate for when subjected to constant source of heat and cold.

RO1: Several Arduinos will be subjected to a source of Heat to ascertain at when temperature the Arduino ceases to function.

RO2: Several Arduinos will be subjected to a source of cold to ascertain at what temperature when the Arduino ceases to function.

RQ4: How accurate are Commercially Available off the Shelf (COTS) GPS Shield/Modules for the Arduino Platform.

RO1: Acquire a variety of GPS Modules for the Arduino platform.

RO2: Ascertain the accuracy of the GPS Modules. Confirm against iPhone, and Garmin GPS Systems.

RQ5: What is the largest Data Packet Size that the Arduino can handle during Tx/Rx.

RO1: Ascertain the largest data packet transfer size via the Tx/Rx module of choice for the Arduino Wireless Sensor Network (AWSN).

RQ6: Can the Wireless Sensor Network be deployed to monitor and record level of Radiation and Environmental Factors within the abandoned city of Pripyat. and Chernobyl

RO1: Design, Build, Develop and Test an Arduino based Wireless Sensor Network.

RO2: Conduct validation and verification of the Wireless Sensor Network locally before deployment.

RQ7: Deploy the Wireless Sensor Network (WSN) to Pripyat.

RO1: Travel to and deploy the Wireless Sensor Network in and around the Abandoned city of Pripyat.

RO2: Monitor and record data in a suitable retrieval system (MySQL etc).

Pripyat Field Research Phase:

This will be dictated by the current situation between Russia and Ukraine, I'm hoping by Academic year 3 or 2025, things will have settled to allow entry to Ukraine, a fallback option could be Fukushima (Japan)* or Windscale (UK).

*Cost implications.

c) IMPORTANCE AND ORIGINALITY OF THE RESEARCH

(This should be related to a brief literature review of the field of study)

On the 25th April 1986 at the Chernobyl Nuclear Power Plant (ChNPP), No.4 reactor operators were preparing to conduct a safety test of their backup generators, to ascertain how long the turbines would spin and supply power to the main circulating pumps following a total loss of power to the plant [3]**.** On the 26th April 1986 at 01:23, It is safe to say that the test failed spectacularly resulting in the complete destruction of reactor no.4 and spreading radioactive debris all over the immediate area and winds carried radioactive particles (Caesium-131, Caesium-137, Plutonium-241) many thousands of miles over the following days and weeks, The Ukrainian government (Which was part of the Soviet Union) tried in vain to cover up the incident as they scrambled to try and clean up the disaster. It was 2 days post incident that winds had blown radioactive particles as far north as Sweden and alarms started to sound at the Forsmark nuclear power plant [4]. Not surprising that the Russian government denied all knowledge of an incident at Chernobyl, even though Swedish officials had presented evidence proving that there was a problem [5]. It was not until Sweden threaten the Russians with a report to the International Atomic Energy Agency (IAEA)[6] about the fallout and the Russian government had no choice but to concede. 48 hours after the incident, news stations around the world started reporting about the incident.

"The scram just before the sharp rise in power that destroyed the reactor may well have been the decisive contributory factor." [16]

There is an article on the History Channel's web site that states one of the members of the commission observed that at 21:00 on the 26th of April 1986 "The reactor suddenly awakened, and three powerful explosions illuminated the night sky and launched red hot pieces of graphite into the air and that it was a striking spectacle" [7]. I have read many papers and many books about the disaster; I have not yet found any other information relating to three subsequent explosions in the evening of the disaster, I feel this would be a very significant event that would be mentioned in all literature and in all documentaries, yet I have not seen any additional information relating to further explosions.

Pripyat was the first immediate external casualty of the incident as winds pushed a cloud containing radioactive debris, aerosols and gasses over the town [8] most people were asleep and indoors, so they were protected by the immediate dangers of the radiation. The gases and aerosols that formed in the cloud contained Xenon-131 and Krypton-85 which reached an altitude of almost 2 kilometres and had moved over the city. Many people had been woken by the loud explosion from the plant and were standing outside watching the aftermath of the incident, as a large column of smoke rose above the damaged plant and a blue column of light could also be seen (Cherenkov Affect) [9]. There is arguments whether residents went and watched from the "Bridge of Death" in the HBO miniseries it depicts residents standing on the bridge watching the incident as radioactive debris "Fallout" lands on them rendering them all contaminated, however other articles state that this did not happen.

Observing from the roof of the ten story Pripyat Hotel looking in the direction of the town of Chernobyl could be seen a long column of multicoloured busses (1100 in total) stretching over 12 miles, waiting for the order to move into Pripyat to evacuate the residents [10]. At around 1:30pm (36 Hours after the initial incident) the buses were ordered to move towards Pripyat eventually one bus would stop outside each accommodation block, residents had begun complaining of headache and vomiting, this is the beginning signs of radiation sickness [11]. The residents would board the buses having been told to only pack light, wearing light clothes and only packing essential items (Food, Money, Medicines). Residents were told that they would only be gone for a few days, however, they would never be allowed to return to their homes.

"*We were told that the evacuation was for three days only, and that there was no need to take anything, so I left wearing my bath robe."* [12].

A team of scientists in Bangladesh created an Arduino based radiation monitoring system along with other sensors to monitor their local environment [13], they used a standard Arduino Uno [14] microcontroller connecting a Radiation Geiger Muller printed circuit board other sensors including gas sensors to capture levels of Carbon Dioxide, Nitrogen Dioxide and Sulphur Dioxide and Ammonia, their system being used in a small poultry farm, although it give me some inspiration as to how I would like to build an develop my own system, it was not used in a heavily radiated area so would only pick up very small amounts of background radiation and would not need to account for contamination from the ground and nearby buildings or flora and fauna.

Scientists at NASA (National Aeronautics and Space Administration) in the United States of America (USA) conducted a similar experiment on the Arduino platform for their CubeSat programme, identifying at what point the Arduino will cease to function when subjected to a source of Radiation [15], I have not yet been able to determine what the source of radiation is as they do

have unrestricted access to a nuclear reactor it could be anything from Cobalt, Uranium, Plutonium or Strontium. This will need further investigation.

There is currently no research that I have been able to find that covers the Internet of Things (IoT) and its use in monitoring levels of radiation and environmental factors within the abandoned city of Pripyat. I have checked sources such as:

1. Google Scholar.
2. Elsevier.

So in summary, my research will cover all aspects in regards o the Chernobyl incident of 1986 and the subsequent years of clean up and de-contamination in and around Pripyat and other areas of the Chernobyl Exclusion Zone, and ultimately designing and building and developing my own Arduino wireless Sensor Network (AWSN) to monitor, capture and record environmental and radiation levels within the Chernobyl Exclusion Zone and more refined the area of Pripyat, the abandoned city that houses the workers of the Chernobyl Nuclear Power Station.

d) PROPOSED RESEARCH METHODS

A mixture of Laboratory and field work will need to be conducted to complete my research these include the following:

Mini Projects to get to final goal.

Project 1:	Tx/Rx Range Investigation (Inc Bad Weather Testing)			
Description:	To ascertain the total operating range of a variety of Transmission/Receiving modules for the Arduino platform.			
Project Type	**Sufficient Evidence:**	**Evaluation Process:**	Training Required:	Technical Support:
Lab and Field Work	Sample Size	Data Analysis	No	None Required
Ethical Implication:	Outside the scope of the Universities Ethics policy.			

Project 2:	Arduino Radiation Tolerance Investigation			
Description:	Irradiate several Arduino microprocessors to ascertain their operating lifespan when subjected to a source of gamma radiation (Cobalt 60 (^{60}Co)).			
Project Type	**Sufficient Evidence:**	**Evaluation Process:**	**Training Required:**	**Technical Support:**
Laboratory	**2 Previous Papers**	Data Analysis.	Yes – From DCF.	Yes - From DCF.
Ethical Implication:	Outside the scope of the Universities Ethics policy.			
Funding	NNUF Funding Being Applied For. **Deadline:** 30th November 2022. National Nuclear User Facility (NNUF) Funding.			

Project 3:	Arduino Temperature Tolerance Investigation			
Description:	Investigate the temperature tolerance of the arduinos when subjected to a source of heat and cold.			
Project Type	**Sufficient Evidence:**	**Evaluation Process:**	**Training Required:**	**Technical Support:**
Laboratory	Sample Data	Data Analysis	No	No
Ethical Implication:	Outside the scope of the Universities Ethics policy.			

Project 4:	Arduino GPS Module Accuracy Investigation.			
Description:	Investigate the accuracy of (COTS) GPS module for the Arduino platform.			
Project Type	**Sufficient Evidence:**	**Evaluation Process:**	**Training Required:**	**Technical Support:**
Field Work	Sample Data	Data Analysis	No	No
Ethical Implication:	Outside the scope of the Universities Ethics policy.			

Arduino Wireless Sensor Network:

1. Design, Build and Develop an Arduino Wireless Sensor Network (AWSN) to capture and record Levels of Radiation and Environmental factors before deployment to Pripyat.

Field Experiment Phase:

1. Deploy the Arduino Wireless Sensor Network (AWSN) in the field (Pripyat) for a full 12-month period.

Data Analysis:

1. Collect Primary data from the Arduino Wireless Sensor Network over a 12-month period.

2. Analyse secondary data sets collected over previous years.
3. Analyse data using either Python or R to visualise data in a human readable format.
    a. No specific training is needed.
    b. No Technical Support is needed.

Ethical Implications:

My Research does not involve Live Humans or Animals.

I do not intend to carry out any physical research on humans or animals, I do not believe my project needs any ethical approval, however there will be safety considerations that will need to be taken for some of my projects, especially the Radiation Tolerance Investigation at the Dalton Nuclear Institute, I believe training will be provided on the morning of experiment day at the institute.

BIBLIOGRAPHY (20 references should suffice and the bibliography should be presented in the style approved within your discipline. You may wish to refer to your supervisor if unsure).

1. Arduino.cc. (2021). *Arduino Uno R3*. [Online]. Arduino.cc. Last Updated: 2021. Available at: https://store.arduino.cc/products/arduino-uno-rev3 [Accessed 31 October 2022].
2. Manchester University. (2022). *Cumbria Facilities*. [Online]. Dalton Nuclear Institute. Last Updated: 2022. Available at: https://www.dalton.manchester.ac.uk/research/facilities/cumbria-facilities/ [Accessed 31 October 2022].
3. World Nuclear Association. (2016). *Chernobyl Accident 1986*. [Online]. World Nuclear Association. Last Updated: 2016/2022. Available at: https://world-nuclear.org/information-library/safety-and-security/safety-of-plants/chernobyl-acciden [Accessed 31 October 2022].
4. Forsmark Nuclear Power Plant. (2022). *Forsmark Nuclear Power Plant*. [Online]. https://group.vattenfall.com. Last Updated: 2022. Available at: https://group.vattenfall.com/se/var-verksamhet/forsmark/forsmark-nuclear-power-plant [Accessed 31 October 2022].
5. Berdnyk, L. (25th April 2022). *How Sweden Found Out About The Chernobyl Disaster and Alerted The Rest of The World*. [Online]. Swedes in the States. Last Updated: 25th April 2022. Available at: https://swedesinthestates.com/how-sweden-found-out-about-chernobyl-and-alerted-the-rest-of-the-world [Accessed 31 October 2022].
6. IAEA. (1998). *International Atomic Energy Agency*. [Online]. International Atomic Energy Agency. Last Updated: 2022. Available at: https://www.iaea.org [Accessed 31 October 2022].
7. Plokhy, S. (2018). *The Chernobyl Cover-Up: How Officials Botched Evacuating an Irradiated City*. [Online]. history.com. Last Updated: 10th May 2019. Available at: https://www.history.com/news/chernobyl-disaster-coverup [Accessed 2 November 2022].
8. Medvedev, Z. (1990). *The Legacy of Chernobyl*. Oxford, UK: Basil Blackwell Ltd. p.41.
9. IAEA. (2022). *What is Cherenkov Radiation?*. [Online]. International Atomic Energy Agency. Last Updated: 28th July 2022. Available at: https://www.iaea.org/newscenter/news/what-is-cherenkov-radiation [Accessed 11 November 2022].
10. Medvedev, G. (1989). Evacuation. In: Medvedev, G. (Ed). *The Truth about Chernobyl*. London, UK: I.B Tauris & Co Ltd. p.181.
11. Lallanilla, M. (2022). *Chernobyl: Facts about the world's worst nuclear disaster*. [Online]. livescience.com. Last Updated: 18th May 2022. Available at: https://www.livescience.com/39961-chernobyl.html [Accessed 16 November 2022].
12. Tsechelsakaya, IP. Medvedev, G. (1989). Evacuation. In: Medvedev, G. (Ed). *The Truth about Chernobyl*. London, UK: I.B Tauris & Co Ltd. p.185.
13. M. S. Miah, M. A. Rahman and M. M. Hossain, "Air Quality Monitoring in Bangladesh: Use of Arduino with SO2, NH3, NO2 Sensor and Radiation Kit- A Part of Smart City Planning," *2021 4th International Symposium on Advanced Electrical and Communication Technologies (ISAECT)*, 2021, pp. 1-5, doi: 10.1109/ISAECT53699.2021.9668387.
14. Arduino S.r.l. (2021). *Arduino Uno R3 Microcontroller*. [Online]. Arduino CC. Last Updated: 2022. Available at: https://store.arduino.cc/products/arduino-uno-rev3 [Accessed 16 November 2022].
15. Violette, D.P. (2014). *Arduino/Raspberry Pi: Hobbyist Hardware and Radiation Total Dose Degradation*. [Online]. NASA.gov. Last Updated: 2014. Available at: https://nepp.nasa.gov/workshops/eeesmallmissions/talks/11%20-%20THUR/1430%20-%202014-561-%20Violette [Accessed 17 November 2022].
16. International Nuclear Safety Advisory Group (INSAG), The Chernobyl Accident: Updating of INSAG-1, INSAG Series No. 7, IAEA, Vienna (1993).

17. INTERNATIONAL NUCLEAR SCIENCE, TECHNOLOGY AND ENGINEERING CONFERENCE 2015 (INUSTEC2015) Volume: AIP Conf. Proc. 1704, 030012 (2016)
18. A. Holovatyy, V. Teslyuk, M. Lobur, Y. Sokolovskyy and S. Pobereyko, "Development of Background Radiation Monitoring System Based on Arduino Platform," *2018 IEEE 13th International Scientific and Technical Conference on Computer Sciences and Information Technologies (CSIT)*, 2018, pp. 121-124, doi: 10.1109/STC-CSIT.2018.8526696.
19. Guo C-Y, Lin T-L, Hsieh T-L. A Solar-Rechargeable Radiation Dosimeter Design for Radiation Hazard Zone Located with LoRa Network. *Quantum Beam Science*. 2022; 6(3):27. https://doi.org/10.3390/qubs6030027
20. Agus Taufiq and Subur Zanuar 2020 *J. Phys.: Conf. Ser.* **1436** 012078
21. iNuSTEC2015: International Nuclear science, technology and engineering conference 2015; Negeri Sembilan (Malaysia); 17-19 Aug 2015; (c) 2016 AIP Publishing LLC; Country of input: International Atomic Energy Agency (IAEA)

TEMPORAL PLAN (Outline the time frame envisaged for your research tasks).

Gantt Chart is attached with the Email in a separate document.

RESEARCH ETHICS

(The research must be ethically sound, and must be conducted in accordance with the University's *Research Ethics: A Handbook of Principles and Procedures*, and with be within the code of conduct for the specific discipline. Specific ethical issues, including confidentiality, must be addressed within the proposed plan of work above):

1. My research will be conducted under the guidelines of (please tick):

☒ The University of Gloucestershire's Handbook of Research Ethics

☐ The University of Gloucestershire's standard protocols in the exercise physiology laboratory

☐ The NHS Research Governance Framework

☐ The British Sociological Association

☐ The British Psychological Society Code of Conduct

☐ The British Educational Research Association

☐ The Market Research Society

☐ The Oral History Association

☐ Other (please state and attach copy) _ _ _ _ _ _ _ _ _ _

2. Does this proposal contain elements that make reference to the University Research Ethics Committee mandatory?

☐ Yes ☒ No

(Please see *Research Ethics: A Handbook of Principles and Procedures* Part A, section 6, and Guidelines for Working with Children and Young People)

3. Any specific issues concerning the ethics of this research that require particular comment are detailed in section d) Proposed Research Methods on page _ _ [please enter page number].

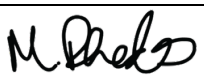
STUDENT CHECKLIST

Before submitting your Project Approval Form to your Supervisor, please confirm that you have:

☒Completed the form in full.

☒ Checked the ethical implications of your project with your supervisor. Students requiring clearance from the University's Research Ethics Committee (UREC) need to take responsibility for submitting the appropriate paperwork to UREC and gaining the Committee's approval before commencing any data collection.

☒Signed and dated this page (by hand or electronically, but not a typed signature).

STATEMENT BY THE APPLICANT	
I wish to apply for approval to undertake the above mentioned degree on the basis of the proposals given in this application. I confirm that the particulars given are correct and I understand that, except with specific permission, I must prepare and defend my thesis in English. I have read and understood the University of Gloucestershire's *Research Ethics: A Handbook of Principles and Procedures.* I agree to abide by the regulations, and the *Research Ethics Principles and Procedures* of the University.	
Signature: 	Date: 17/11/2022
NOW SEND THE COMPLETED AND SIGNED FORM TO YOUR SUPERVISOR(S)	

SECTION 2: SUPERVISORS TO COMPLETE

RECOMMENDATION BY THE SUPERVISORY TEAM

I/We support this application and believe that the candidate has the potential to complete successfully the programme of work proposed. I/We recommend that the applicant's *Project* for the above research degree be submitted for review. I/We also confirm that the student has been advised of the review process and the possible outcomes.

Attach the ***Project Approval - Supervisor Pre-submission checklist*** to this document before submitting to the PGR Lead for review.

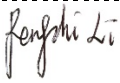
Are there any budget implications beyond those discussed at candidate's interview stage?

☒ No

☐ Yes. Please contact budget holder (usually the Head of School) and notify School PGR Lead

FIRST SUPERVISOR

Name (including title): Pengzhi Li

SIGNATURE: 	Date: 17/11/2022

SECOND SUPERVISOR

Name (including title):

SIGNATURE:	Date: Click here to enter a date.

SECOND SUPERVISOR 2 (if applicable)

Name (including title)

SIGNATURE:	Date: Click here to enter a date.

NOW EMAIL THE COMPLETED FORM AND PROJECT APPROVAL PRE-SUBMISSION TO YOUR SCHOOL PGR LEAD OR NOMINATED LOCATION HIGHLIGHTED ON THE PROJECT APPROVAL PRE-SUBMISSION CHECKLIST FOR YOUR SCHOOL

SECTION 3: SCHOOL TO COMPLETE – PGR Lead or nominated member of School staff

☐ The student checklist has been completed

☐ The student indicates the project should be referred to UREC in the 'Research Ethics' section. A copy of the Project Approval form has been passed to the Officer of UREC. [*Note: Approval for the project at REC should normally be confirmed before the PGR Lead passes the Project Approval form on for review*.]

☐ Student and Supervisor(s) signatures have been added to the form

☐ The Project Approval - Supervisor Pre-submission checklist has been received

☐ The supervisory team is appropriate and legal in relation to the Academic Regulations for Research Degree Provision.

If no, outline action to be taken below (e.g. appointment of second supervisor with specific skill range etc.)

If any of the boxes are not checked, please return the Project Approval form to the student for completion/correction.

☐ I confirm that this form has passed an administrative check.

The following have been nominated as reviewer(s) for this proposal.

Reviewer 1:

Reviewer 2:

PGR LEAD NAME:	Date: Click here to enter a date.

NOW EMAIL THE FORM TO THE REVIEWER(S)

SECTION 4: PGR LEAD TO COMPLETE	
FINAL RECOMMENDATION OF THE REVIEWERS I confirm the final recommendation of the reviewer(s) as ☐ APPROVE ☐ REJECT (where a different award pathway can be offered, please note below) ☐ OFFER ALTERNATIVE AWARD PATHWAY ……	
Signature:	Date: Click here to enter a date.

NOW EMAIL THE COMPLETED FORM TO THE STUDENT, SUPERVISOR(S) AND RESEARCH ADMINISTRATION OFFICE