# QUB - Mechanical and Aerospace Engineering
# PhD Project Description

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| **Title:**<br> Developing physics-constrained Deep-Learning Neural Network to simulate coupled multiphysics nonlinear thermal plasma | |
| **Theme: Aircraft Thermal Protection system** | |

**Project description**:
This project seeks to develop a physics-constrained deep-learning neural network (DL-NN) method to solve highly nonlinear coupled PDE to model multiphysics engineering problems. The current progress in PC hardware does not match the ambition in simulating multiphysics problems to investigate process physics and design optimization. This project does not aim at developing a DL-NN that requires large simulation data for training, but rather focuses on developing physics-constrained DL-NN without simulation data through minimizing the residual terms of the PDE and is based on analytic functions for accelerated and improved estimate. Adapting the new emerging technique on a coupled multiphysics problem that has highly nonlinear process will require developing the DL-NN through investigating improved activation functions, adaptive learning rate, and novel multilayer NN-architecture. The developed computational methodology will be applied to simulate the lightning strike (LS) impact on composite structures.

**Aims and Objectives:**

(1) Develop a novel DL-NN architecture to capture the highly nonlinear multiphysics process;

(2) Investigate integrating analytic functions that represent PDE steady-state or partial-transient solutions (faster training and enhanced estimate);

(3) Investigate improved NN-activation functions and NN-adaptive learning schemes;

The basic multi-layer perceptron of a NN must be transformed to adapt to highly nonlinear process without the need for expensive training.

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| **Key skills required for the post:**<br>Matlab – knowledge of partial differential equations | |
| **Key transferable skills that will be developed during the PhD:**<br>Multiphysics simulation – Thermal Plasma Physics – Deep Learning Neural Network simulation | |
| **Lead supervisor:** | Name and contact details of person leading the research.<br>Dr Gasser Abdelal – g.abdelal@qub.ac.uk |
| **Other supervisor(s):** | Name(s) of anticipated other supervisors on project<br>Prof. Brian Falzon – b.falzon@qub.ac.uk |
| **Funding mechanism:** | Yet to be secured / UK only / UK and EU / UK, EU and International<br>TBC |
| **Application closing date:** | Specific date or until suitable candidate appointed. |
| **Guaranteed stipend:** | This can include a basic stipend and any guaranteed top-up (if available).<br>N.B. Stipend for 20-21 is not yet confirmed. Base stipend for 19/20 is £15,009. |
| **Conditional top-up available:** | Amount and condition<br>N/A |

**PhD students in the School may have the opportunity to apply to be demonstrators on undergraduate modules. Compensation for this can amount to in excess of £2,400 per year.**

*Queens University Belfast is a diverse and international institution which is strongly committed to equality and diversity, and to selection on merit. Currently women are under-represented in research positions in the School and accordingly applications from women are particularly welcome.*