Proposal for Faculty Grant for International Travel
Arindam Banerjee (Mechanical Engineering & Mechanics)

- **Professional and personal goals for the visit:**

A greener portfolio of energy generation technologies is integral to a sustainable energy future. Hydrokinetic Energy (HKE) systems are a new class of renewable energy devices that offer ways to tap the kinetic energy of the flowing river/stream or tides and convert it into electrical energy. The fundamental advantage of HKE systems lies in their ability to harvest energy without obstruction of the flow by dams or through diversions as required in many micro-hydro (run of the river) facilities. Our research focus over the last several years has been to understand the fundamental physics that is at the core of design and development of next generation HKE systems. We have published our results in several international journals and have attracted grant funding from the U.S. Navy.

However, in spite of the preliminary success, my attempt to understand the dynamic interactions of the HKE systems with their river/oceanic environment has not made significant progress due to lack of advanced technologies in the continental United States. When it comes to the portfolio of renewable energy, Europe and most importantly, the United Kingdom is several decades' ahead in laboratory and field-scale investigation. This proposal is effort is to bridge that gap and actively collaborate with researchers of international repute at the Universities of Manchester and Oxford in the U.K. My personal goal is to establish a working relationship with foreign universities in UK, exchange students during summer to work on facilities here at Lehigh and at U.K. and create the path for enhancing international visibility and recognition for Lehigh.

- **Expected outcomes:**
  - **Short-term:** Upon completion of my trip, we will look at opportunities to expand our collaboration with other LU faculty. The PI is currently collaborating on this research with Prof. Panos Diplas, Professor & Chair of Civil and Environmental Engineering. Such interactions will also benefit the *Lehigh Wave Energy team* [Profs. Kishore (ECE), Blum (ECE), Snyder (ISE) and Lamadrid (Eco)] and several other colleagues in Civil Engineering [Profs. Suleiman, Troy and Bocchini]. In addition, there will be future scope to look at the problem more holistically and explore environmental impact of these devices by collaborating with Prof. Dork Sahagian (EES).
  - **Long-term:** With Manchester and Oxford as the main partner, we will approach the National Science Foundation and the Department of Energy for establishing a US-UK consortium for HKE harvesting. The NSF PIRE program is one such funding mechanism that will be explored.

- **Nature of interaction:**

The focus of the interaction is integrating experimental measurements across different scales (laboratory scale to field scale) for developing a database for validation and verification of computational models of marine hydrokinetic energy systems. The visit will enable the teams to become more familiar with the combinations of expertise and unique testing facilities that exist in both campuses. Prof. Banerjee will give several research presentations on tidal and wave energy at the University of Manchester and also disseminate his research findings at the

Oxford Tidal Energy Workshop, an event hosted annually between the Universities at Manchester and Oxford and attracts the leading researchers from UK and Europe to present their research findings.

- **Name(s) of the foreign academic institution(s):** University of Manchester

- **Name(s) of faculty members (or equivalent) in these institutions:** Prof. Tim Stallard

- **Pre-trip planning:**
  A letter of invitation from Prof. Timothy Stallard is attached. I will prepare to give couple seminars and use that opportunity to convey the attributes of my research and that of the LU collaborators (listed above) to foster a collaboration. Before the trip, Prof. Stallard and I will develop a list of "action items" with short term and long term collaboration goals between our institutions.

- **Follow-up steps upon return to campus:**
  Upon completion of my trip, I plan to send a graduate (PhD) student to Manchester to work with Prof. Tim Stallard at their experimental facilities. This will allow us to test our devices and benchmark models across different scales encompassing a broad range of applications. Prof. Stallard will also send a student to perform similar validations studies. In addition, Prof. Banerjee will submit a brief written trip report upon return to campus to the Vice President for International Affairs with copies to Prof. Gary Harlow, MEM chair and Prof. John Coulter, Interim Dean, RCEAS. Prof. Banerjee would be also willing to join the rest of the recipients to give a short oral presentation about their experiences to faculty interested in applying for this program in future as well as newly hired faculty at Lehigh.

- **Proposed Budget**
  - Roundtrip Airfare (peak time: EWR-LHR): $1800
  - Lodging Rates (5 days in Oxford @ $168/day + 5 days in Manchester @ $193/day based on Department of State per diem for either location): $1805
  - Travel costs within UK (LHR to Oxford to Manchester and back to LHR): $400
  - **Total Cost: $4005** (if there are any additional expenses, the applicant will bear it)
  - **Date:** March, 2017 (exact dates to be decided)

The University of Manchester

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Chair, Faculty Grant for International Connections
c/o Stacy Burger
Office of International Affairs
Coxe Hall – 3rd floor
Lehigh University

30 January 2016

Dear Sir / Madam,

I am delighted to write this letter to Dr. Arindam Banerjee extending him an invitation to visit University of Manchester to extend our collaboration of topics of tidal and wave energy harvesting. I have considerable experience on working on various hydro-structural problems in the field of tidal and wave energy harvesting and have been leading the experimental and computational initiatives at the School of Mechanical, Aerospace and Civil Engineering at the University of Manchester, U.K. My research concerns offshore renewables including tidal stream, wave energy and offshore wind. Ongoing projects in my group addresses the loading and response of tidal stream and wave devices to unsteady and extreme loads and interactions amongst arrays of devices.

Dr. Banerjee and I have been collaborating on efforts to enhance our understanding of tidal turbines to enable performance prediction of such devices in harsh marine environments. Our group at Manchester has recently contributed to two industry-academia marine energy projects that were commissioned by the Energy Technologies Institute to accelerate the development of a marine energy industry in the UK and two major EPSRC funded challenge calls linked to the UK Centre for Marine Energy Research. Within the Performance of Arrays of Wave and Tidal Stream Systems (PerAWaT) project, we have designed and conducted experimental studies to improve understanding of individual turbine wakes and the loading and energy yield of turbines within arrays. On the Reliable Data Acquisition Platform for Tidal (ReDAPT) project we have developed the EDF open-source CFD solver Code_Saturne to enable blade-resolved Large Eddy Simulation of a prototype tidal stream turbine in realistic turbulence. On the EPSRC Marine Energy Challenge project X-MED CFD and SPH are being further developed to enable prediction of extreme loads on tidal stream turbines due to turbulence and current and due to impact loads.

I believe that the efforts of my group complements well the research activities currently being undertaken at Lehigh University by Prof. Banerjee (MEM) and Prof. Diplas (CEE). An opportunity for Prof. Banerjee to visit us would facilitate alignment of UK/EU and US research efforts in this research area. Prof Banerjee would be welcome to exchange research expertise with the group in Manchester. A visit aligned with the Oxford Tidal Energy workshop (typically held third week March) would also allow for wider dissemination of research findings during the visit. I have been a member of the scientific committee of this workshop series since the inaugural event in 2012 and this now attracts many UK and EU groups active in the tidal stream research community. If you have any questions for me, please do not hesitate to contact me.

Yours faithfully,

Dr Tim Stallard, MEng, DPhil.
Senior Lecturer and Postgraduate Research Admissions Tutor.