

# Piezoelectric Vibration Energy Harvesting Under Uncertain Environment – A Short Course

Rice University  
3-5 April 2018  
Lecturer: Prof S Adhikari

## Lecture Schedule

### Day1: Introduction to Energy Harvesting and it Applications

#### Lecture 1

- *Introduction to piezoelectric vibration energy harvesters*

The need for piezoelectric vibration energy harvesters, potential applications, summary of linear piezoelectricity, Euler-Bernoulli theory for vibrating cantilevers, finite element modelling, base excitation of cantilevers, electromechanical coupling. Reduced order modelling, first mode of vibration, equivalent single-degree-of-freedom coupled model, systems with and without inductors.

#### Lecture 2

- *Energy harvesting due to harmonic excitations*

Frequency domain analysis, frequency response function, resonance and effect of material and electrical damping. Effect of piezoelectric parameters. Analytical model for Optimal parameter design under harmonic excitations

### Day 2: Analysis of linear energy harvesters

#### Lecture 3

- *Energy harvesting due to random excitations and optimal design*

Broadband excitation, Gaussian random process, stationary random vibration, numerical methods for stochastic differential equations  
Derivation of mean harvested power, analytical methods for contour integral in complex plane, unconstrained and constrained optimisation

#### Lecture 4

- *Analysis of nonlinear energy harvesters*

Nonlinear model for energy harvesting. Various nonlinear harvesters, development of governing equations using energy principles, example of cantilever beam with tip mass, governing equation and nonlinear reduced model, equilibrium points and linearization, numerical simulation, comparison with experiments

(each lecture will last approximately two hours)