

## Dr. PRATEEK BENHAL

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I am a Ph.D. graduate from the Mechanical Engineering Department, at the University of Canterbury at Christchurch (UC), New Zealand. Recently completed five years of postdoctoral tenure from the USA and looking for suitable scientific research job opportunities. My research combines the interdisciplinary fields of engineering, biology, and physics which aims to bridge the gap between micro/nanorobotic, cyber-physical, and synthetic biology. In the near future, I foresee myself to be leading a research team to work on magnetoelectric and dielectrophoresis based biosensors and new products integrated with AI for various biomedical applications. My most significant selling point would be my varied, colorful experience working with industries and academia across continents. Worked as a team member and as a leader.

**Specialties:** Drug delivery, lab-on-a-chip, magneto/electro hydrodynamics, cell culture, dielectrophoresis, magnetic fields, microfluidics, electrochemistry, photolithography, microfabrication, machine learning, micro and nanorobotics and algorithm development.

### SUMMARY

- Over 5+ years of postdoctoral research work experience in microfluidic and cell culture assay with electromagnetic fields. Manipulated E. Coli bacteria and vibrio using an electromagnetic field with closed-loop controls; acquired work experience in bacteria and mammalian cancer cell culture and microscopy imaging.
- Over 5+ years of work experience in designing and analyzing next-generation magnets (permanent and electromagnets).
- Over 5+ years of work experience in developing advanced algorithms to manipulate colloidal particles, magnetic beads, cells, and biological entities such as mitochondria, oocytes, and bacteria. Research experience in biological cell rotation and handling using AC electric fields.
- Ph. D graduate: Major research concentration on electrokinetic effect on biological cells.
- Editorial board member of ESTEEM journal of science and technology, University Technology Mara, Pinang, Malaysia.
- Reviewer and member in International Journal of Engineering Research & Technology (IJERT)
- Experienced in photolithography, L-edit, micro/nanofabrication, cell-based microfluidic assays.
- Over 10+years of research and teaching experience in laboratory management, such as setting up a bio-safety lab from scratch, assisted control system lab experiments. Taught control system engineering and mechatronics design class, 2011-2013 at Mechanical engineering department, University of Canterbury.
- “Powertrain hybrid vehicle design engineer” in General Motors (GM), Bangalore India, 2009-2011.
- Over 4+year research experience in Matlab, COMSOL V4.3, and ABAQUS analysis software.
- Over 2+ year of experience on Unigraphics NX3, Pro-E parametric 3D design software.
- Parametric Solid 3D modeling Simulation and Analysis experience.

### EDUCATION

**University of Canterbury, NZ • Ph.D.** Mechanical Engineering. May. 2014  
Major: bioengineering and micro-robotics • **UC Premier doctoral research scholarship**

**University of Tennessee, Knoxville, USA • MS** Mechanical Engineering. Dec. 2007  
Major: robotics, controls and vibrations, Graduate research fellow

**Visvesvaraya Technological University (VTU), Karnataka, India • B.E.** Mechanical Engineering. Sep. 2005  
Major: robotics and controls

### PEER-REVIEWED PUBLICATIONS

#### Journal publication:

##### Published

1. Chen, Z., Wang, Z., Quashie, D., **P. Benhal** et al. “Propulsion of magnetically actuated achiral planar microswimmers in Newtonian and non-Newtonian fluids”, Scientific Reports (2021), 21190 (11). <https://doi.org/10.1038/s41598-021-00153-5>
2. **P. Benhal**, D. Quashie, U. K. Cheang, and J. Ali, “Propulsion kinematics of achiral microswimmers in viscous fluids”, Applied Physics Letters (2021), 118 (20). <https://doi.org/10.1063/5.0048277>
3. **P. Benhal**, D. Quashie, Y. Kim, J. Ali, “Insulator Based Dielectrophoresis: Micro, Nano, and Molecular Scale Biological Applications”, MDPI: Sensors Journal, 2020, 20(18). <https://doi.org/10.3390/s20185095>
4. M. Shimoji, B. Ramaswamy, M. I. Shukoor, **P. Benhal**, A. Broda, S. Kulkarni, P. Malik, B. McCaffrey, J-F. Lafond, A. Nacev, I.N. Weinberg, B. Shapiro, D. A. Depireux, “Toxicology Study for Magnetic Injection of Prednisolone into the Rat Cochlea, European Journal of Pharmaceutical Sciences”, 2019, 126: 33-48. <https://doi.org/10.1016/j.ejps.2018.06.011>.

5. **P. Benhal**, A. Broda, D. Najafali, P. Malik, A. Mohammed, B. Ramaswamy, D. A. Depireux, M. Shimoji, M. I. Shukoor, B. Shapiro, "On-Chip Testing of the Speed of Magnetic Nano-and Micro-Particles Under a Calibrated Magnetic Gradient", *Journal of Magnetism and Magnetic Materials (JMMM)*, 2018, **474**: 187-198. <https://doi.org/10.1016/j.jmmm.2018.10.148>
6. D. Depireux, B. Ramaswamy, M. Shimoji, M. Shukoor, **P. Benhal**, B. Shapiro, "Magnetic delivery of therapy to the cochlea", *Hearing Journal*, 2017, **70**(7): 4-20. <https://doi.org/10.1097/O1.HJ.0000521759.00742.6b>.
7. **P. Benhal**, J. G. Chase, W. H. Wang, P. Gaynor, and B. Oback, "Multiple-cylindrical Electrode System for Rotational Electric Field Generation in Particle Rotation Applications", *International Journal of Advanced Robotic Systems (IJARS)*, 2015, **12**:84. <http://doi.org/10.5772/60456>.
8. **P. Benhal**, J. G. Chase, W. H. Wang, P. Gaynor, and B. Oback, "AC electric field induced dipole-based on-chip 3D cell rotation", *Lab Chip Journal*, 2014, **14**(15): 2717-2727. <http://dx.doi.org/10.1039/C4LC00312H>.

#### Conference proceeding:

1. Z Chen, Z Wang, D Quashie, **P Benhal**, J Ali, UK Cheang, Propulsion of magnetically actuated achiral swimmers in complex fluids, *Bulletin of the American Physical Society (APS)*, USA, 2020.
2. D. Quashie Jr, **P. Benhal**, Z. Chen, Z. Wang, U. Cheang, J. Ali, Magnetic Propulsion and Manipulation of Achiral Swimmers in Polymer Fluids, *AfroBiotech Conference*, USA, October 2020. (Poster and Oral presentation)
3. **P. Benhal**, J. G. Chase, *System Identification and Stochastic Estimation of Dielectric Properties of a Spherical Particle using AC-induced Electro-rotation*. Proceedings of the 2015 International Conference on Process Control (PC), Štrbské Pleso, Slovakia, June 9 – 12, 332–337, 2015.
4. **P. Benhal**, J. G. Chase, W. H. Wang, P. Gaynor, and B. Oback, *Dielectrophoresis-based 3D cell rotation through the integration of bottom and vertical electrodes*, 17th International Conference on Miniaturized Systems for Chemistry and Life Sciences, MicroTAS (2013), Freiburg, Germany, October 27-31, MicroTAS-2013 conference proceedings, 970-972, 2013.
5. **P. Benhal**, J. G. Chase, W. H. Wang, P. Gaynor, and B. Oback, *Rotational electric field simulation on a spherical particle for dielectrophoresis-induced rotation*, 7th International Conference on Microtechnology in medicine and biology conference proceedings, 2013.
6. **P. Benhal**, J. G. Chase, W. H. Wang, P. Gaynor, and B. Oback, *A micro-device integrating vertical and bottom electrodes for 3D cell rotation*, *Advanced materials, and nanotechnology conference (AMN-6) proceedings*, Presented poster and paper in Feb 11-15th 2013.
7. **P. Benhal**, J. G. Chase, W. H. Wang, P. Gaynor, and B. Oback, *Dielectrophoresis based 3D cell rotation through the integration of bottom and vertical electrodes*, *Gordon research conference*, 2012-2013.
8. **P. Benhal**, J. G. Chase, W. H. Wang, P. Gaynor, and B. Oback, *Harmonic simulation study towards frequency-dependent 3D cell rotation for biomedical applications*, ANZ. Micro and Nano-fluidics symposium, Wellington, NZ. April 12-13, 2012.
9. **P. Benhal**, J. G. Chase, W. H. Wang, P. Gaynor, and B. Oback, *Cell rotation in Non-uniform AC field by Orthogonal Polynomial Electrodes for enucleation applications*, *Student & Postdoc MacDiarmid Symposium*, 2011.

#### Patents:

1. Provisional patent filed, "Magnetic Manipulation of Mitochondria", University of Maryland Invention Disclosure, LS-2019-122, 2019-2020.

#### RESEARCH WORK EXPERIENCE

**Postdoctoral Research Associate**, Florida State University, Tallahassee, FL, USA.

**Jan. 2020-Apr. 2021**

\* Research focus on Colloidal particle manipulation using electromagnetic fields, bacteria, and micro/nanomagnetic particle manipulation with precise control for targeted therapeutics.

##### • Research summary:

- Cultured E. Coli bacteria tagged with magnetic beads and integrated electromagnetic imaging system to control the movement of bacteria in various polymer viscous media. Precise control of bacteria movement provides valuable information regarding navigating bacteria to the desired locations in the human body for targeted cargo delivery.
- Manipulated bacterial flagella tagged with avidin-biotin magnetic coated beads using electromagnetic fields. Designed an electromagnet coil system and calibrated the magnetic fields. Measured magnetic fields experimentally and numerically.
- Microscopy imaging, and cell culture of mammalian secondary cell lines. Gained research work experience in handling confocal, epifluorescent, darkfield, phase-contrast microscopy. Experience gained in handling Nikon inverted microscope system. Performed design of experiments (DOE) to experiment for cell and bacteria assays.
- Isolated mitochondria from endothelial and breast cancer cells to investigate the response to electromagnetic fields.
- 3D bio-printed breast cancer cells in bioinks, tested the viability by injecting bacterial cells to investigate host-pathogen interactions.
- FEM/FEA based CFD computation of magnetohydrodynamic fields for rare earth element separation.
- Worked on managing the lab logistics and gained experience in maintaining BSL-2 lab environments. Accumulated experience in working with biohazard.
- Guided 4-Ph.D students, 3-Master, and several undergraduate students in lab management and research. Mentored K-12 high school students on bacterial motility studies.

- Collaborated with researchers to work on imaging virus and cell imaging using microscopy and advanced imaging techniques.

**Postdoctoral Research Associate**, Fischell Department of Bioengineering, University of Maryland, College Park, MD, USA.

**Apr. 2016-Dec. 2019**

\* Research focus on magnetic nanoparticle manipulation for targeted **drug delivery** applications such as the delivery of drug through the skin and ear tympanic and inner membranes.

- Research summary:
  - Designed next-generation disc magnets to push/pull magnetic nanoparticles with drug into human cochlea for efficient targeted therapeutics. Provided fundamental framework in magnet design and optimized magnetic force applied on magnetizable objects such as steel ball or thumb pin to achieve push force on the magnetic nanoparticle. Analyzed and experimented with push/pull force on magnetic nanoparticles delivered into eye cornea layers.
  - We investigated delivering magnetic nanoparticles through tissue barriers. For this purpose, I obtained proficiency in tissue and gel (agarose and gel) culture.
- Innovation summary:
  - We designed a next-generation combination-disc magnet. We innovated a simple system to find the disc magnet force applied on magnetizable objects. 3D printed magnetic holder to place disc magnet in the needed position. Design and perform validation studies on novel magnets using DOE methodologies.
  - We developed a simple lab on a chip device to manipulate magnetic nanoparticles using innovative neodymium disc magnets and permanent rare earth magnets. Quantified nanoparticle motion in the chip using a custom-built image processing algorithm. Employed high-resolution epifluorescence inverted and an upright microscope to detect magnetic nanoparticles aggregate motion under calibrated magnetic field. Collected and analyzed particle motion data using statistical techniques.
- Mentor/teaching summary:
  - Guided 2-undergraduate and 1-graduate student relating to magnetic nanoparticle manipulation studies.
  - Mentored 3 undergraduate students for “Terps in space” program competition. We innovated a system to create sodium alginate microspheres in a silicone tube filled with calcium chloride. These spheres housed fertilizable egg cells and aid in organism growth. We investigated the sphere behavior along with organism growth habits in microgravity.
- Impact: submitted a provisional patent for next-generation magnets, two first-author publications under progress, Co-authored work published in the journal of hearing.
- Experience gained: microchip for magnetic nanoparticle handling, a device to measure the magnetic force applied on objects, nanodrop, statistical analysis, image processing, tissue, and gel culture, mentoring students.

**Postdoctoral Researcher**, Advanced algorithm and control system lab, CVUT, Prague, CZ

**Nov. 2014-Oct. 2015**

\* Research focus on automation of dielectrophoresis-based cell manipulation and commercialization of biochip is under progress and control system integration.

- Research summary: *control system identification methods to automate cell rotation and dielectrophoresis-based particle manipulation strategies. Cell torque rotation transfer function is determined, and the numerical algorithm was used to estimate hidden parameters for system automation.* Developed an advanced algorithm in Matlab for an automated system to determine dielectric properties and a system identification approach to detect and estimate the transfer function of electrorotation torque on beads and cells. Employed system identification for automation of cell movement tracking and rotation under dielectric fields. Apart from these, I evaluated invention disclosures, reviewed patent literature, and wrote reports to assess inventions’ patentability and commercialization potential.

**Ph.D. Research and Teaching Assistant**, The MacDiarmid Institute and Bioengineering Lab, University of Canterbury \* (Prof. J. G. Chase)

**Jun. 2010-Sep. 2014**

\* Research focus on biochips for automation of mammalian cloning process, with the technology used in biological labs for cell rotation.

- Research summary: designed microfluidic devices with chemical and electrical components to rotate and manipulate bovine cells/oocytes; focused on MEMS device design, modeling, and characterization; 5-year PC-2 cleanroom fabrication and testing experience; strong working knowledge of cell biology and assays.
- Impact: 2 first-author publications, 7-8 conference presentations.
- Lab skills: microfluidic device and cell handling, mammalian cell culture, cell separation, rotation and capture techniques, electronic circuitry and equipment, immunological chemistry, fluorescence microscopy.
- Fab skills: Micro-milling, contact and lift-off photolithography, thin-film deposition (RF-sputter, e-beam evaporation), dry and wet etching (metal, asher, RIE), metrology (SEM, AFM, profile-meter), wafer cleaning (piranha), wafer bonding and dicing, SU-8 and PDMS coating, molding work on glass.
- Computer skills: COMSOL (FEA), Quick field, MATLAB, Uni-graphics, LabVIEW, L-Edit CAD Editor, SolidWorks, SigmaPlot, Mathematica, Maple, C, C++, PI/SQL.
- Office and web: MS Office, Excel, PowerPoint, Windows XP, Vista, Dream weaver, Adobe Photoshop.

- Transferable skills:
  - *Entrepreneurial:* proposed original research, acquired own funding through UC premium postdoctoral research fellowship, and was the postgraduate student representative for Mechanical Engineering Department at UC, NZ.
  - *Leadership:* selected for aspiring leadership conference held at Wellington, NZ in 2012, trained and supervised two junior lab members on lab protocols, led journal club discussions, also chosen as vice president for university student housing at Sonoda campus living apartments.
  - *Communication:* delivered 10+ research presentations, peer-reviewed two research papers for journals.
  - *Analytic:* independently tested hypotheses, designed experiments, and analyzed data.
  - *Organization:* scheduled monthly lab cleanups, managed equipment, and inventory, ordered supplies.
  - *Teamwork:* collaborated with graduate students and clinicians for publications and management.
- Lectured on control system and solid works lab for 1<sup>st</sup> and 2<sup>nd</sup> year Bachelor of Engineering Students in UC.
- Lectured on course materials, organized, and led lab sessions, demonstrated how to write lab reports, conducted office hours, and graded homework assignments and lab reports for a class of more than 120 students.
- Full-time researcher on AC electric field-induced dipole-based 3D cell rotation. Gained in-depth experience working on micro-fabrication, microparticle, and cell handling.

**Powertrain hybrid vehicle design engineer, General Motors, India.**

**Jan. 2009-May. 2010**

- Carried out GD&T for engineering design. Gained in-depth experience in Unigraphics and Teamcenter management.
- Completed advanced hybrid vehicle training and benchmarking sessions.

**Programming consultant, Tecon Solutions Inc., USA.**

**Jan.2008-Dec. 2008**

- SQL backend programming was performed for clients via Oracle PL/SQL programming and debugged codes at the backend. Form's tool was tweaked for clients for better understanding using backend programming.

## SELECTED AWARDS AND GRANTS

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- Assistant in experiments for **Collaborative Collision: COVID-19 Seed Fund**. Florida State University, "siRNAs for Coronavirus Gene Knock-Out Research," May 11, 2020, to August 18, 2020.
- **European Postdoctoral Research grant**, 2014-2015: ~\$90,000, "Support of inter-sectoral mobility and quality enhancement of research teams at Czech Technical University in Prague, CZ.1.07/2.3.00/30.0034".
- **Royal Society of Chemistry, MicroTAS Conference Travel Grant**, 2013: \$500
- Selected as one of the top 150 from 2000 scientific research posters in MicroTAS-2013 conference in Germany named "Dielectrophoresis-based 3D cell rotation through the integration of bottom and vertical electrodes".
- **Premier Ph.D. researcher scholarship grant**, 2010-2014: 17500 NZD/annum, University of Canterbury, NZ.
- **Undergraduate Scholar Award**, 2004-2005: Rs. 5000 (awarded for the best undergraduate project on flowmeter with computer interfacing).
- **Best presentation and paper award, 2005**, State Level paper on "Computational Fluid Dynamics" received 3<sup>rd</sup> prize Vishveshwaraiah Technological University Karnataka, India.
- **3<sup>rd</sup> prize for seminar and paper presentation, 2004, topic "Computer simulation using advanced computational methods"** at SDM College of engineering and technology, Karnataka, India.

## CERTIFICATES

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- General Motors University Finance College certificate, 2010, Certificate name: "Managing Risk Overview".
- The Quantum Internet and Quantum Computers - Technische Universiteit Delft.
- Machine Learning with Python: A Practical Introduction – IBM. Pro-E and ANSYS certified operator.
- Understanding Plants - Part I: What a Plant Knows – Coursera.
- Global Diplomacy – Diplomacy in the Modern World - SOAS University of London.
- Understanding International Relations Theory - Higher School of Economics.

## LANGUAGES

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English • Hindi • Kannada (native, conversational proficiency) • Telugu

## EXTRACURRICULAR LEADERSHIP AND TEAMWORK EXPERIENCE

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Python coding in free time • Professional cricket player for Maryland Cricket League 2017-present. Played professional cricket and soccer for General Motors (GM.) Technical Center, India, 2009-2010 as all-rounder • Postgrad representative during Ph.D. and served as vice president for student housing • website developer at UC postgraduates. •Currently learning intermediate swimming and on track to become a professional swimmer.