

# TRIBOLOGY: FRICTION, WEAR, AND LUBRICATION



PROFESSIONAL EDUCATION 

## OVERVIEW

The study of friction, wear, and lubrication is of enormous practical importance, because the functioning of many mechanical, electromechanical, and biological systems depends on the appropriate friction and wear values. In recent decades, this field, termed tribology, has received increasing attention as it has become evident that the wastage of resources resulting from high friction and wear is greater than 6% of the Gross National Product. The potential savings offered by improved tribological knowledge are immense.

However, most engineers do not have sufficient background in this area. For example, an undergraduate engineering student receives perhaps an hour of instruction in tribology. Moreover, most reference works of tribology provide little guidance to solving real-world problems.

This program presents current insights into tribology, focusing on such fundamental concepts as surface energy, elastic and elastoplastic deformation, micro-fracture, and surface interactions at the micro- and nano-scale. Special consideration is given to the application of fundamental knowledge to control friction and wear behavior through lubrication and the selection of materials and coatings in practical situations. Furthermore, modern experimental methods are discussed and several case studies are used to illustrate how fundamental tribology knowledge can be applied in the design of tribological components and systems.

## WHO SHOULD ATTEND

The program is beneficial for participants who are active or intend to be active in research on some aspect of tribology, and those who have encountered practical friction and wear problems and wish to learn novel methods of solving them.

The course requires at least a bachelor's degree in engineering or physical sciences, including basic courses in mathematics, applied mechanics, materials science, physics, and chemistry. Some lectures introduce advanced concepts in these areas and in physical chemistry and thermodynamics. These will be reviewed where necessary to provide the required background. Industrial experience is preferred.

**Computer Requirements:** Laptops or tablets are not required for this course, but are strongly recommended. Each participant receives digital and hard copies of the course lectures.

## LEAD INSTRUCTORS:

Nam Pyo Suh, Nannaji Saka

**COURSE DATES:** June 22–26, 2020

**COURSE LENGTH:** 4.5 days

**COURSE FEE:** \$4,000

**CEUs:** 2.9

*“A good practical overview of tribology. I didn’t expect it to be as practical/real-world/valuable as it was. I expected it to be “in-the-clouds” mysterious as other tribologists I have come across have acted. I like the courage of the presenters defining what is known, what is estimated, and what is unknown. It has improved my view of tribology’s legitimacy.”*

COMPRESSOR ENGINEER,  
THERMOKING CORPORATION

*“Excellent program. Exceptional opportunity to learn from world-wide known tribologists.”*

SR. COATING SPECIALIST, ROLLS-ROYCE

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## THE COURSE INCLUDES

- Description of surface topography, physico-chemical aspects of solid surfaces, and surface interactions
- Mechanics of solid elastic and elastoplastic contacts
- Laws of friction, mechanisms of friction, friction space, stiction, stick-slip, and surface temperature
- Various modes of wear: adhesive, delamination, fretting, abrasive, erosive, corrosive, oxidational (mild and severe), melt, and the wear-mechanism maps
- Types of lubrication: boundary, solid-film, hydrodynamic, elasto-hydro-dynamic lubrication
- Case studies: sliding contacts, rolling contacts, bearing design, coating selection, and lubrication
- Design of tribological surfaces and troubleshooting tribology problems
- Survey of tribological testing devices
- The seminal role that tribology plays in the satisfactory functioning of mechanical, electrical, electromechanical, and biological systems
- Appreciation of the importance of tribology in minimizing energy consumption, extending product life, and protecting the environment
- The laws, mechanisms, and models of friction, wear, and lubrication—spanning nano, micro, meso, and macroscales
- Recognition that tribological properties are the properties of the system as a whole, not just of the individual
- Methodologies of design and troubleshooting tribological systems
- Protocols and procedures of accelerated and long-term tribological testing

## INSTRUCTORS

### NAM PYO SUH

Dr. Nam Pyo Suh was the 13<sup>th</sup> and 14<sup>th</sup> President of the Korea Advanced Institute of Science and Technology (KAIST). He is also the Ralph E. & Eloise F. Cross Professor, Emeritus, MIT, and Chairman of Boston Tribology Associates.

### NANNAJI SAKA

Dr. Nannaji Saka was a Principal Research Scientist and Senior Lecturer in the Department of Mechanical Engineering at MIT. Now he is Vice President of Boston Tribology Associates, Cambridge, MA.

### SAID JAHANMIR

Dr. Said Jahanmir is the President and CEO of Boston Tribology Associates. He is also a past President of ASME.

### NICHOLAS X. RANDALL

Dr. Nicholas X. Randall is Vice-President of Alemnis, a Chartered Engineer (CEng MIM) and Chairman of ASTM Committee G02.40 (Non-Abrasive Wear).

### LAVERN (VERN) D. WEDEVEN

Dr. Vern Wedeven is the founder and President of Wedeven Associates, Inc. He also teaches tribology classes for ABMA.

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*“The course was very good and well worth the cost and time to attend. The content was extensive and informative. The lecturers were impressive and highly knowledgeable in their fields. The social events (dinner and lunch) were superb and provided for wonderful personal and technical exchanges with the attendees and lecturers. I found the dialogue and questions in the classroom to be very interesting and engaging. The classroom accommodations were good and the refreshments provided were of good quality. The discussion of applications, case studies, and problem solving were of most interest.”*

TECHNICAL CONSULTANT, AREVA NP

*“The incorporation of case studies was a great way to break up the lecture environment and allow students to work together, think for themselves, and apply what they just learned. This was my first short program course at MIT and I will certainly be seeking out more in the future.”*

RESEARCH ENGINEER, GATES CORPORATION

*“Not only learned theories of tribology, but also the way of solving engineering problems. The instructors delivered very nice and well prepared talks. I would recommend this class to any of my colleagues in the tribological area.”*

ENGINEERING SPECIALIST, CATERPILLAR INC.

*“I plan use this knowledge to improve my comprehension of the interaction of lubes/surface and in the failure analysis that I make.”*

PRODUCT APPLICATION SPECIALIST, SHELL, BRAZIL

*“The top quality of the professors and lectures, the material, social events, overall organization and logistics were just outstanding!”*

GENERAL MANAGER-DIRECTOR, CUMMINS, ARGENTINA

*“Good conversation and sharing of information with professionals from all over the world.”*

FLUID SYSTEMS ENGINEER, UNITED STATES NAVY

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A SUMMER PROFESSIONAL PROGRAM | JUNE 22–26, 2020

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MA 02139-4307

LECTURE TIME	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
8:30–9:30 AM	<b>1</b> Course Overview (NS)	<b>7</b> Friction of Undulating Surfaces (NS)	<b>13</b> Wear of Polymers (NR)	<b>19</b> Liquid and Solid Lubricants (SJ)	<b>25</b> BioTribology (SJ)
9:30–10:00 AM	Coffee Break	Coffee Break	Coffee Break	Coffee Break	Coffee Break
10:00–11:00 AM	<b>2</b> Introduction to Tribology (NPS)	<b>8</b> Sliding Wear (SJ)	<b>14</b> Wear of Coatings (NR)	<b>20</b> Boundary and Thin Film Lubrication (SJ)	<b>26</b> Nanotribology (NR)
11:00–NOON	<b>3</b> Surface Topography & Properties (NS)	<b>9</b> Abrasive and Erosive Wear (SJ)	<b>15</b> Surface Temperature (NS)	<b>21</b> Fluid Film Lubrication (SJ)	<b>27</b> Frontiers of Tribology (NPS)
NOON–1:30 PM	Lunch Break	Lunch Break	Lunch Break	Lunch Break	Farewell Lunch 12:30 pm
1:30–2:30 PM	<b>4</b> Sliding Friction: Mechanisms and Models (NS)	<b>10</b> Wear of Ceramics and Brittle Materials (SJ)	<b>16</b> Wear-Mechanism Maps (NS)	<b>22</b> EHD Lubrication: Gears and Rolling Element Bearings (VW)	<b>COURSE PRESENTERS:</b> (NPS) Prof. Nam P. Suh (NS) Dr. Nannaji Saka (SJ) Dr. Said Jahanmir (NR) Dr. Nicholas X. Randall (VW) Dr. Vern Wedeven
2:30–3:30 PM	<b>5</b> Tribological Testing I: Theory (NR)	<b>11</b> Case Studies I: Friction (NS, SJ)	<b>17</b> Case Studies III: Wear (SJ)	<b>23</b> Case Studies V: Lubrication (SJ)	
3:30–4:00 PM	Coffee Break	Coffee Break	Coffee Break	Coffee Break	
4:00–5:00 PM	<b>6</b> Tribological Testing II: Demonstrations (NR)	<b>12</b> Case Studies II: Wear (SJ)	<b>18</b> Case Studies IV: Wear of Polymers & Coatings (NR)	<b>24</b> Case Studies VI: EHD Lubrication (VW)	
	Welcome Reception 6:00 pm		Program Dinner 6:30 pm		

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