

## **Precision**

System performance and degradation

## **Reliability**

Component and system reliability

## **Fracture mechanics**

Read fractured surfaces

## **Corrosion and diffusion**

Degradation by corrosion and diffusion

## **Fatigue fracture**

Infinite life and safe life design

## **Contact mechanics**

Load rating of concentrated contacts

## **Friction**

Physics of friction and how to manage

## **Wear**

Wear mechanisms and how to manage

## **Matselect**

Material selection for rolling and sliding contacts

## **Lubselect**

Lubricant selection for rolling and sliding contacts

## **Hydrodynamics**

Lubrication regimes and thin film lubrication

## **Sealing systems**

How they work and might fail

Lifetime performance and reliability

Module	- Learning objectives: After this module you are able to	Keywords
Precision	<ul style="list-style-type: none"> <li>- to qualify and quantify system accuracy, precision, quality and reliability.</li> <li>- find the predominant errors in complex systems</li> <li>- Establish system performance and degradation</li> </ul>	Precision, Accuracy, RMSE, Resolution, repeatability, quality, coefficient of variation, design failures, degradation, bath tube curve, failure rate, hazard rate, relative standard deviation, normal distribution, Weibull, failure cause, failure mode, failure mechanisms, geometrical errors, load induced errors, thermal errors, process errors
Reliability	<ul style="list-style-type: none"> <li>- quantify component and system reliability</li> <li>- apply design procedures to optimize system reliability.</li> </ul>	Component and system reliability, standard normal distribution, probability density, maintenance versus reliability, redundancy, fault tree analysis, critical path, FMEA
Fracture mechanisms	<ul style="list-style-type: none"> <li>- Identify ductile-, brittle- and fatigue fracture</li> <li>- Read fractured surfaces</li> </ul>	Applied stresses, complementary stresses, shear failure, tensile failure, fatigue stages, beach marks, striations, ratchet marks
Corrosion & diffusion	<ul style="list-style-type: none"> <li>- Explain the physics of degradation by corrosion and diffusion.</li> </ul>	pitting corrosion, crevice corrosion, fatigue corrosion, stress corrosion, hydrogen embrittlement, quench cracking
Fatigue fracture	<ul style="list-style-type: none"> <li>- design reliable dynamically loaded screw joints.</li> <li>- drive shafts loaded in rotational bending and torsion.</li> <li>- Design dynamically loaded welded connections.</li> </ul>	Joint stiffness, potential failure mechanisms, thermo-mechanical fatigue, infinite life design, safe life design, fail safe design, damage tolerant design, accelerated testing, SN diagram, endurance limit, safe stress design, rotary beam test, fatigue life models, influence factors, stress concentrations, streamlining of stresses, Palmgren Miner Rule, rain-flow counting, Eurocode 3
Contact mechanics	<ul style="list-style-type: none"> <li>- quantify the load rating of concentrated contacts and understand related failure modes and mechanisms.</li> </ul>	Hertz, elastic deflection, plastic indentation, running in, ratcheting, elastic shakedown, contact stiffness, (sub)surface initiated fatigue, flaking, spalling, pitting, rolling with traction, vibrations, static load rating, dynamic load rating, subsurface stresses, rolling friction, Reynolds slip, Heathcote slip, spinning, EHL, preload

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## Lifetime performance and reliability

Module	- Learning objectives: After this module you are able to	Keywords
Friction	<ul style="list-style-type: none"> <li>- clarify Coulombs friction and its exceptions.</li> <li>- manage friction</li> </ul>	Real contact area, surface chemistry, surface energy, surface topography, characterization, superfinishing, contact conditions, environment, vacuum, temperature effect, oxide layer, ploughing, adhesion, atomic bonding, stick, Abbott bearing area, elastic recovery, plasticity index, polymers, ceramics
Wear	<ul style="list-style-type: none"> <li>- identify wear mechanisms</li> <li>- calculate the wear rate</li> <li>- manage the wear rate of machine components.</li> </ul>	Abrasive wear, adhesive wear, corrosive wear, fretting, false Brinelling, galling, cold welding, seizure, flash temperature, scuffing, ratcheting, particle erosion, electro chemical erosion, Archard's equation, wear rate, non-stationary contact, running in, testing, test conditions
Matselect	<ul style="list-style-type: none"> <li>- find solutions for wear related failures</li> <li>- select the best material combination</li> </ul>	Systematic selection, divergent thinking, coatings, kolsterizing, carburizing, squeaking, stick-slip, several case studies, thread galling, solid lubricants, MoS <sub>2</sub> , graphite, self-lubricating polymers, ceramics, HVOF
Lubselect	<ul style="list-style-type: none"> <li>- identify lubrication regimes</li> <li>- clarify seizure load</li> <li>- categorize lubricants and performance additives</li> <li>- select the best lubricant.</li> </ul>	Stribeck curve, boundary lubrication, mixed lubrication, running-in, base oils, synthetic lubricants, viscosity index improvers, boundary lubricant additives, lubricant life additives, engine oils, fuel efficiency, compounded oils, food grade lubricants, environmental compatible, compatibility with polymers and elastomers, testing, stress cracking, swelling, shrinking, greases, trends and innovations
Hydrodynamics	<ul style="list-style-type: none"> <li>- model Hydrodynamic Lubrication (HL) using the Reynolds Equation</li> </ul>	Analytical and numerical modelling, Mitchell step, Rayleigh step, cavitation, journal bearings, attitude angle, stability, whirl, lemon bore bearings, water lubrication, Multiphysics, soft EHL
Sealing systems	<ul style="list-style-type: none"> <li>- Design sealing systems</li> <li>- Identify the possible failure mechanisms</li> </ul>	Rotary, reciprocating, contactless, oil resistant, physics of failure, smart sealing systems, lip seals, wave seals, mechanical face seals, gas seals, pumping seals, high pressure seals, piston-ring sealing, surface textures

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