

MASTER OF MECHANICAL ENGG. EXAMINATION, 2025

(1st Semester)

PRINCIPLES OF TRIBOLOGY

Time: Three hours

Full Marks: 100

Missing data, if any, may be assumed.

Answer any five questions. All parts of same question must be answered together.

1.
 - a) Explain the different surface layers of a typical metal surface.
 - b) Distinguish between physisorption and chemisorption.
 - c) Distinguish between roughness, waviness, lay and flaw.
 - d) How to remove form error from roughness data in surface profilometry?
 - e) A rough surface profile is sinusoidal with wavelength λ and amplitude A_0 . Show that R_a of the profile is independent of wavelength. 3 x 4+8
2.
 - a) Explain G-W model of contact of rough surfaces with assumptions.
 - b) For an exponential distribution of asperity heights, show that average area of contact is independent of load.
 - c) A ceramic ball of radius 5mm is pressed into a hemispherical recess of 10mm radius in a steel plate. Elastic modulus, Poisson's ratio and hardness of ceramic material and steel are 450 GPa and 200 GPa, 0.3, 0.3, 20 GPa and 5 GPa respectively. Find the normal load to initiate yielding in steel plate. Calculate the radius of contact and the depth at which yield first occurs. 10+4+6
3.
 - a) What is adhesion? How does it differ from cohesion?
 - b) A rubber sphere of diameter 20 mm is brought in contact with a flat smooth glass plate with an initial joining load of 4 g. Now if external load is gradually reduced, explain the contact radius vs. load behavior with the help of graphs for the following two situations:
i) the experiment is carried out in normal atmospheric condition ii) the experiment is carried out in vacuum. Mention the respective theories to explain the behavior.
 - c) What is stiction? State the remedial methods.
 - d) Explain elastic adhesion index and plastic adhesion index. 4+8+4+4

[Turn over

4.
 - a) Explain the causes for friction at the contact between two surfaces. Hence explain the basic theories of friction.
 - b) Consider a micro-scale friction measurement using a hard ball of radius 2.83 mm sliding against a soft and flat surface. The overall friction coefficient is measured as 0.25, and the groove produced during sliding has a width of 1 mm. The interfacial shear strength at the contact is found to be one-tenth of the bulk value. Assuming friction due to multiple mechanisms acting in additive mode, calculate the contribution from different mechanisms towards friction.
 - c) Explain how friction of polymers differs fundamentally from that of metals.

8+8+4
5.
 - a) Explain flash temperature and the use of radiation detectors for its measurement.
 - b) Explain the need for surface engineering. Briefly classify the methods of surface engineering.
 - c) Explain briefly the principle methods of physical vapor deposition process.

8+6+6
6.
 - a) Explain Archard's theory of adhesive wear. How to distinguish between mild wear and severe wear?
 - b) Explain abrasive wear. Explain how it differs from adhesive wear and corrosive wear.
 - c) Explain how rate of erosive wear depends on angle of attack for brittle and ductile materials.
 - d) In a solid particle erosion test of steel plate, the erosion ratio is found to be 10^{-4} at an impact velocity of 50m/s and an impact angle of 20° . Find the proportion of displaced material that result in wear debris if hardness and density of steel be 2.4 GPa and 7.8 Mg/m³.

5+5+5+5
7. Write short notes on (any Four):
 - a) Atomic Force Microscope
 - b) Wear Regime Map
 - c) Pin-On-Disc Test Setup
 - d) Weierstrass Mandelbrot Function
 - e) Hard facing
 - f) Surface Profilometer

5 x 4

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