



UNIT I

Failure Mechanisms - II

Engineering Materials and Metallurgy

KARTHICK B

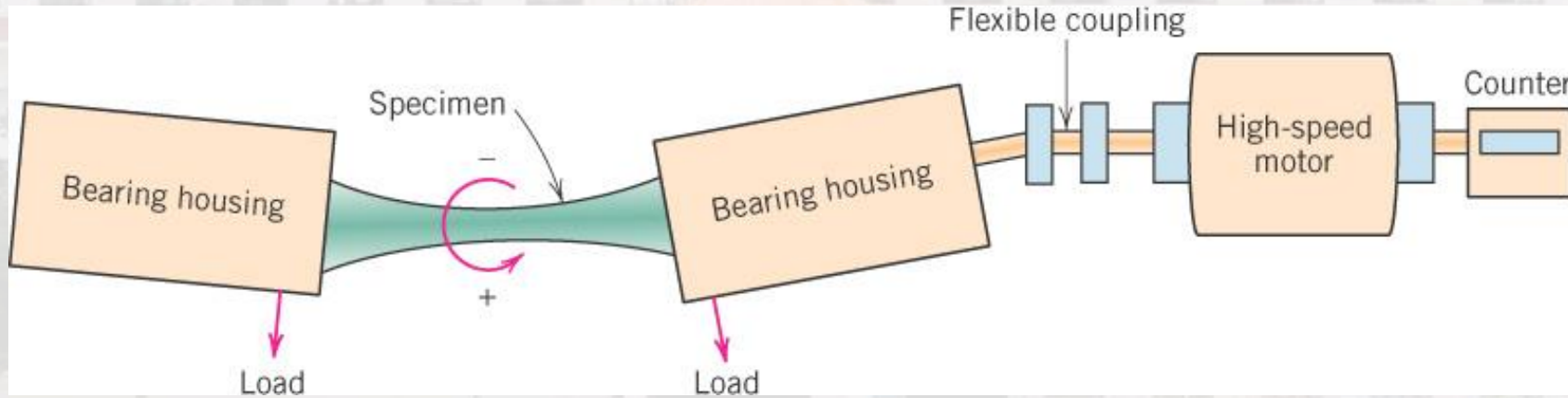
ASSISTANT PROFESSOR / MECHANICAL ENGG



Failures in High Speed Machines



Fatigue



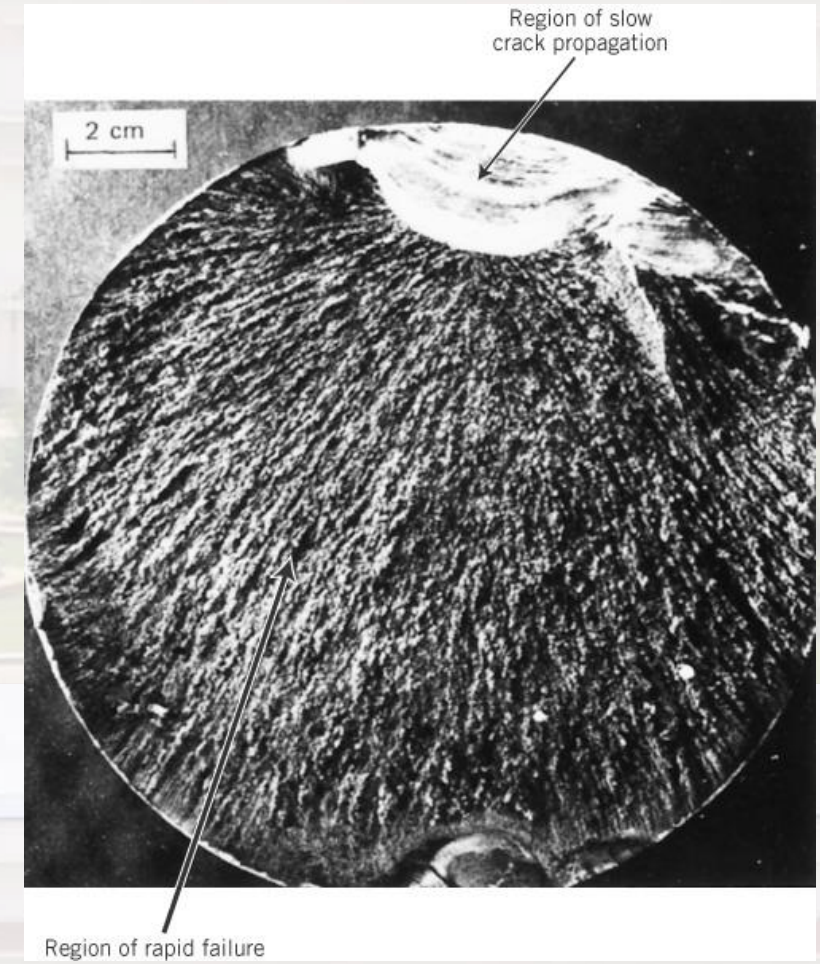
Fatigue testing apparatus for rotating bending test

- Fatigue is a form of failure that occurs in structures subjected to **dynamic stresses over an extended period**.
- Under these conditions it is possible to fail at stress levels considerably lower than tensile or yield strength for a static load.
- Common failure in bridges, aircraft and machine components.



Fatigue

- Fracture surface with crack initiation at top Surface shows predominantly dull fibrous texture where rapid failure occurred after crack achieved critical size.
- Fatigue failure
 1. Crack initiation
 2. Crack propagation
 3. Final failure

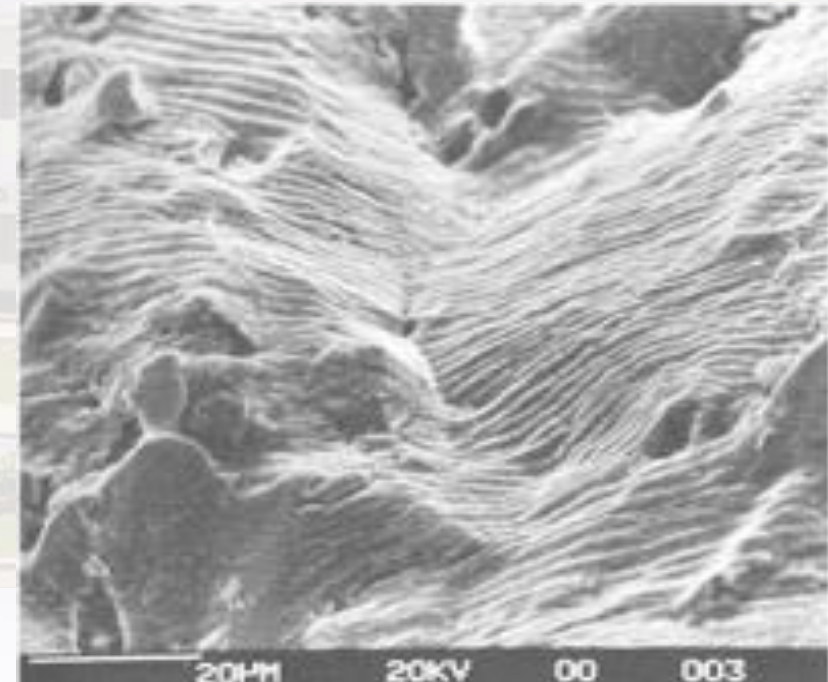




Fatigue



- Striations are close together indicating low stress, many cycles.
- Widely spaced striations mean high stress few cycles.





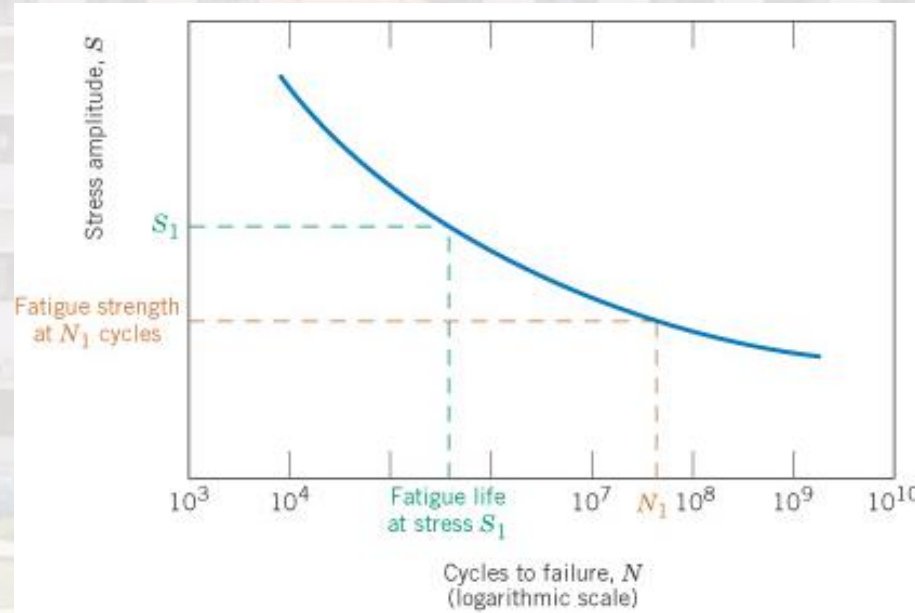
Fatigue



- Fatigue failure is brittle in nature, even in normal ductile materials;
- There is very little plastic deformation associated with the failure.
- The image shows **fatigue striations** (microscopic).



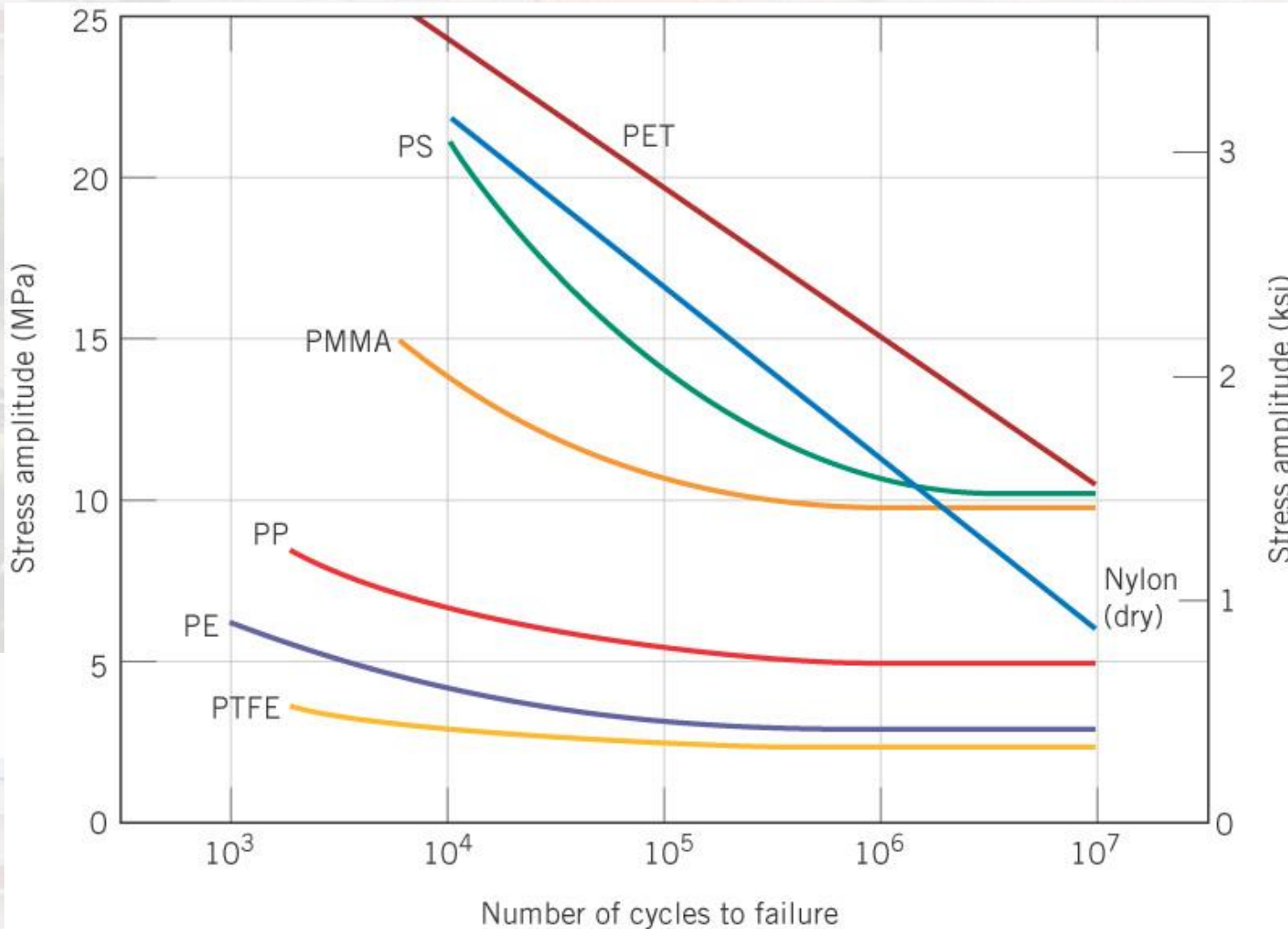
S-N Curves



- A specimen is subjected to stress cycling at a maximum stress amplitude; the number of cycles to failure is determined.
- This procedure is repeated on other specimens at progressively decreasing stress amplitudes.
- **Typical S-N behavior: the higher the stress level, the fewer the number of cycles.**



Fatigue Curves for Polymers

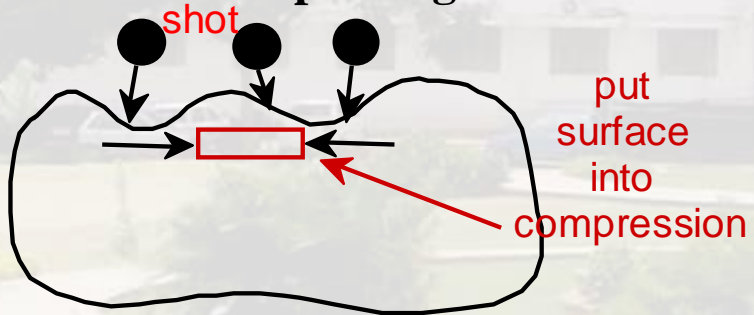




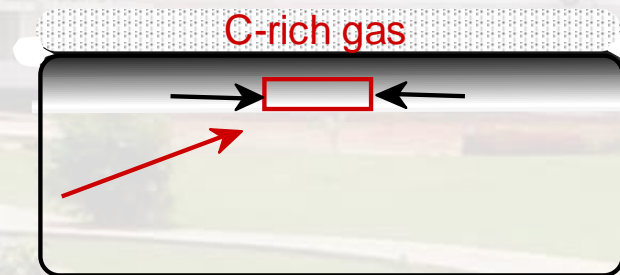
Improving Fatigue Life

1. Impose a compressive surface stress (to suppress surface cracks from growing)

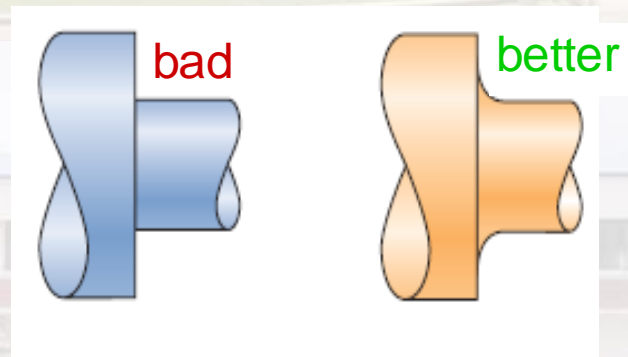
Method 1: shot peening



Method 2: carburizing



2. Remove stress concentrators.





Creep

- Materials are often placed in service at **elevated temperatures ($>0.4 T_m$)** and exposed to **static mechanical stresses**.
- Examples are **turbine rotors in jet engines** and steam generators that experience centrifugal stresses and high pressure steam lines.
- Creep is **time dependent, permanent deformation of the material when subjected to a constant load or stress**.





Creep

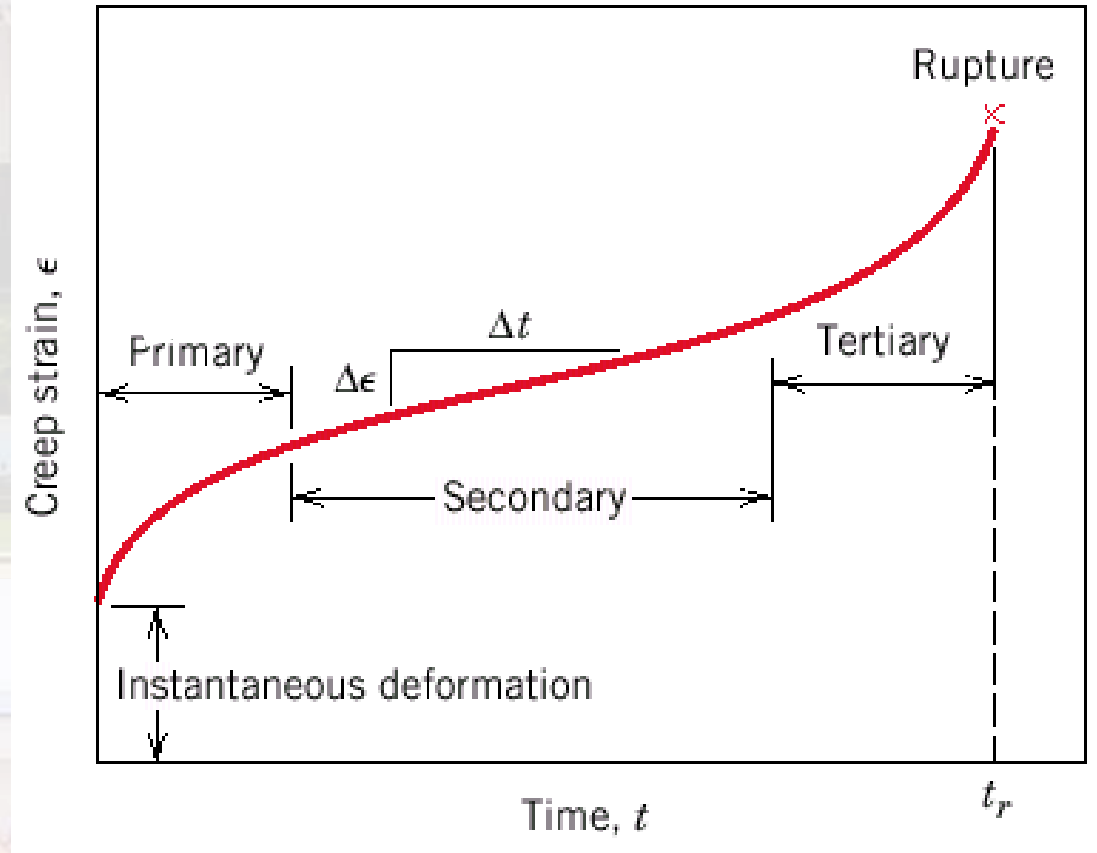


Sample deformation at a constant stress (s) vs. time

Primary Creep: slope (creep rate) decreases with time.

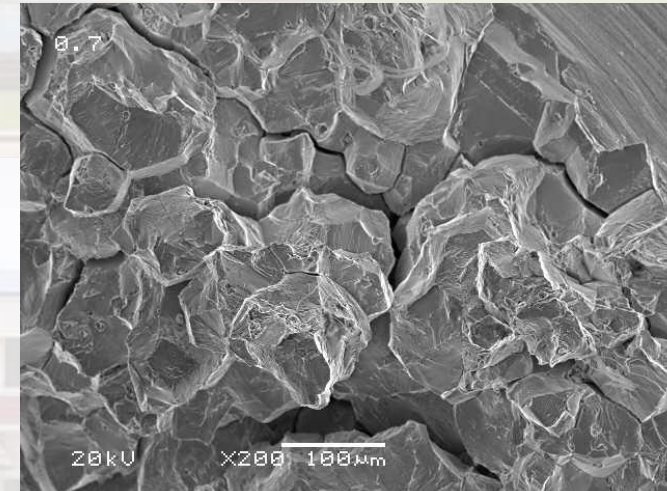
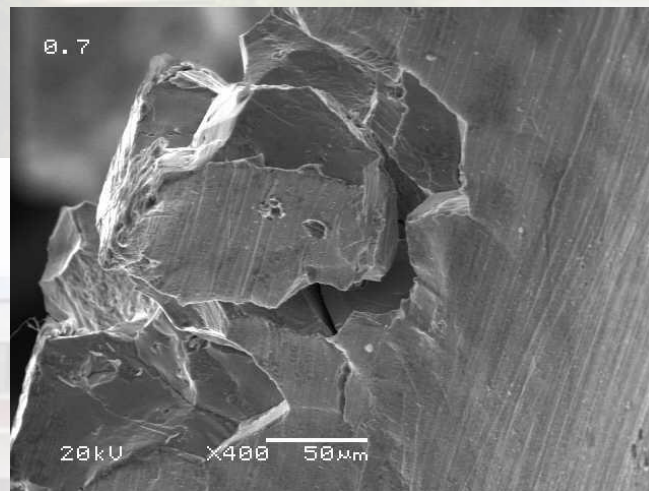
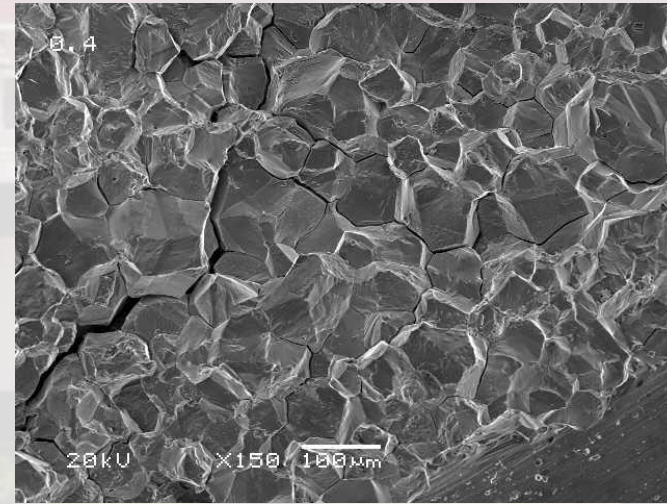
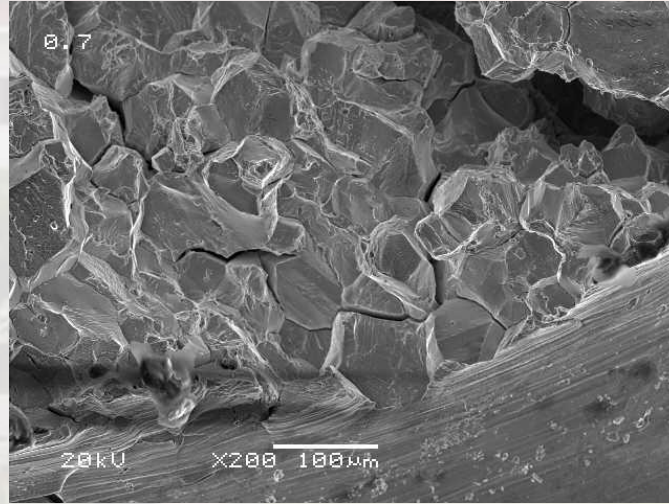
Secondary Creep: steady-state i.e., constant slope.

Tertiary Creep: slope (creep rate) increases with time, i.e. acceleration of rate.





Creep Failure





THANK YOU

ASSESSMENT

<https://play.kahoot.it/v2/?quizId=8ce2264c-edd6-4e9c-8178-56875f8d4197>