

Shape Memory Alloy Knowledge Evaluation Test

1. What is the basic mechanism of the shape memory effect (SME)?
 - a. Deformation due to the motion of mixed dislocations
 - b. Interstitial diffusions within the crystal lattice structure
 - c. Phase transition in a crystal lattice structure
 - d. Grain boundary growth after recrystallization
 - e. None of the above

2. Which of the following are not characteristics of the Martensite Phase?
 - a. A material in the undeformed Martensite phase is the same size and shape as the Austenite phase of the SMA material
 - b. Martensite can be stress induced
 - c. Martensite has a monoclinic crystal structure
 - d. Martensite has a much higher yield strength than other phases of SMAs

3. Which of the following are not traits of the Pseudo-elastic effect?
 - a. If a material has been deformed by a load and then unloaded, it remains in its deformed shape until heated to its transformation temperature.
 - b. Pseudo-elasticity occurs without a temperature change
 - c. When no load is applied the material is composed of Austenite
 - d. All of the above are traits of Pseudo-elastic materials

4. What is the name for the high temperature phase for Shape Memory Alloys?
 - a. Ferrite
 - b. Pearlite
 - c. Cementite
 - d. Martensite
 - e. None of the Above

5. It is possible for some shape memory alloys to undergo a shape change with both heating and cooling as opposed to just heating.

- a. True
- b. False

6. Identify the phases for the shape memory crystal structures:

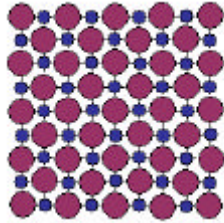


Figure 1 – Cubic
Crystal Structure

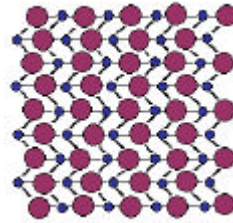
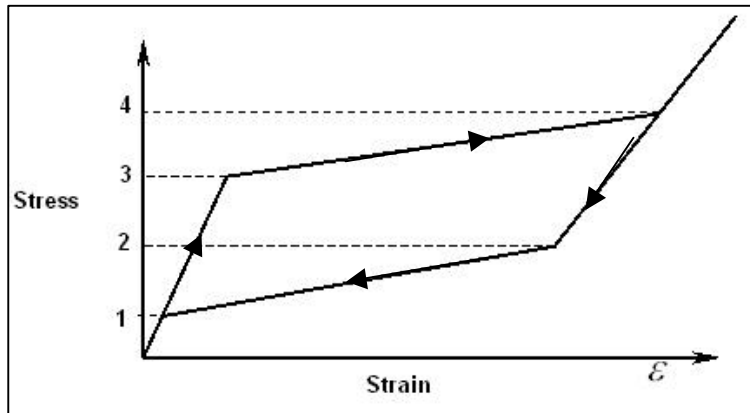


Figure 2 – Monoclinic
Crystal Structure

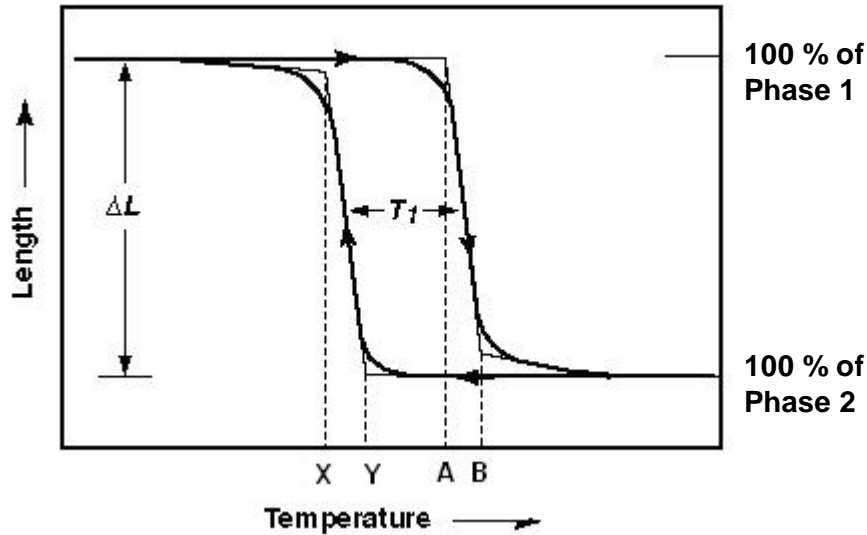
- a. Figure 1 – Low Temperature Phase; Figure 2 – High Temperature Phase
- b. Figure 1 – High Temperature Phase; Figure 2 - Low Temperature Phase

7. Which point below represents the amount of stress where the sample has become completely Austenitic?



- a. 1
- b. 2
- c. 3
- d. 4

8. The figure below represents a typical transformation versus temperature curve for a specimen under constant load (stress) as it is cooled and heated. Which of the statements below is True?



- X represents the Martensite Start Temperature
 - Y represents the Martensite Start Temperature
 - A represents the Austenite Finish Temperature
 - B represents the Austenite Finish Temperature
 - Both a and c are True
 - Both b and d are True
9. Which of the following examples represents a use for the pseudoelastic effect for SMAs?
- Fire Safety Valve
 - Spring in a Heat Engine
 - Flexible Frames of Glasses
 - These are all examples of the pseudoelastic effect
10. Which is not a limiting factor for use of shape memory alloys?
- Cost
 - Efficiency of a system with SMAs
 - Phase cooling rate
 - All of these are limiting factors

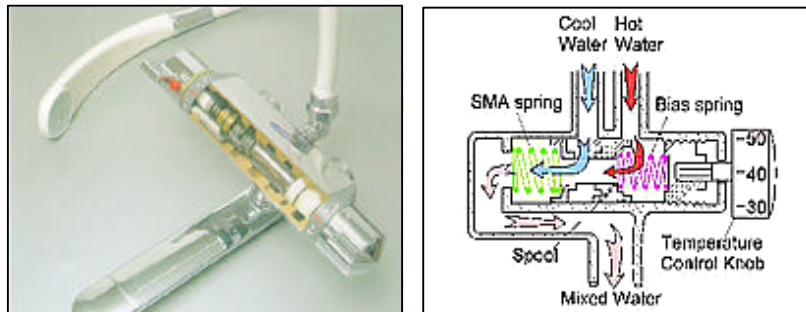
11. Which of these is not an advantage for using shape memory alloys in a system?

- a. Efficiency of a system with SMAs
- b. SMAs can do mechanical work from in an increase in thermal energy
- c. Speed at which transformation can occur
- d. SMA actuators are silent

12. Which of the following is not a medical application for a shape memory alloy?

- a. Bone fracture repairs
- b. Cardiovascular wire filters
- c. Dental Braces
- d. All of these are applications for SMAs

13. The following picture shows how an SMA is used in a mixing valve. Which of the following describes what drives the transformation in the SMA for this example?



- a. An increase in strain in the SMA spring
- b. Resistance heating in the SMA
- c. A thermal energy increase from the water
- d. None of the above

14. Which of the following best describes the type of application for the mixing valve in Problem 13?

- a. Sensor
- b. Actuator
- c. Sensor and Actuator
- d. Coupling

15. Given the simple heat engine represented in the pictures below answer questions 15 and 16. Additional Information:

- The wire is resistance heated.
- The current is measured with an Ammeter.
- Mass = 0.5 kg
- Displacement of Mass = 5 cm
- Current through Spring = 2 Amp
- Voltage through Spring = 6 V



T = 0 s



T = 5 s

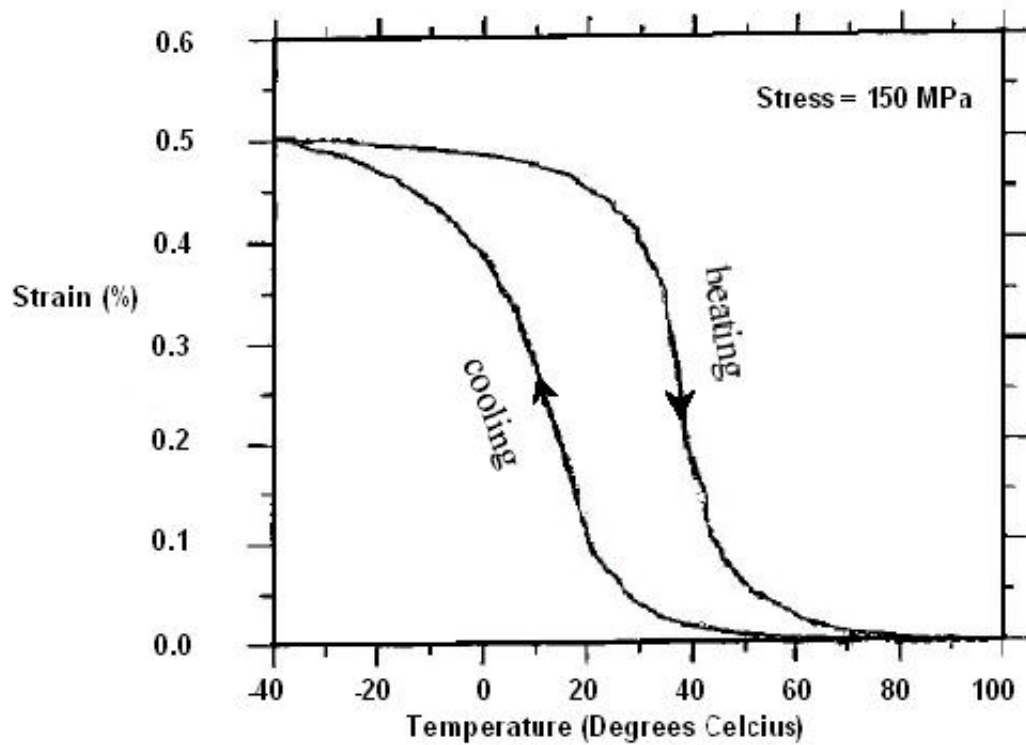
What is the amount of work done by the SMA spring?

- a. 0.025 J
- b. 4.9 J
- c. 0.245 J
- d. 9.8 J
- e. None of the above

16. What is the efficiency of the SMA from problem 15?

- a. 3.12 %
- b. 0.408 %
- c. 12.0 %
- d. 24.5%

17. The figure below illustrates a Strain-temperature curve for NiTi SMA wire under a 150 MPa applied stress. What is the value for the modulus of elasticity for the low temperature phase?



- a. 150 MPa
- b. 300 MPa
- c. 30 GPa
- d. 160 GPa
- e. 300 GPa

18. The modulus of elasticity is the same for both the high and low temperature phases.

- a. True
- b. False

19. The Thermal Conductivity of an SMA does not change with a phase change.

- a. True
- b. False

20. Given the following information what is the value for the transformation strain in the austenitic phase?

Material Properties for NiTi SMA

Physical Constants	
$E^A = 70.0 \text{ GPa}$	$\alpha^A = 11.0 \times 10^{-6} \text{ K}^{-1}$
$E^M = 30.0 \text{ GPa}$	$\alpha^M = 6.6 \times 10^{-6} \text{ K}^{-1}$
Parameters characterizing the phase transformation	
$M^{0s} = 281 \text{ K}$	$A^{0s} = 285 \text{ K}$
$M^{0f} = 250 \text{ K}$	$A^{0f} = 303 \text{ K}$

- a. 0.0
- b. 0.023
- c. 0.046
- d. 0.12

21. When modeling the mechanical behavior of SMAs, which strain can be found from Hooke's law ($\sigma = E\epsilon$)?

- a. Transformation strain
- b. Elastic strain
- c. Strain due to thermal expansion
- d. Interstitial strain

22. A 100% martensite SMA wire of length L is fixed to a spring of stiffness k in such a way that there is initially no force on the spring or the SMA wire. The initial temperature is equal to the austenite start temperature corresponding to zero stress. Heat is added to the SMA wire until it completely transforms into austenite. Immediately after the phase transformation is complete, what is the deflection of the spring?

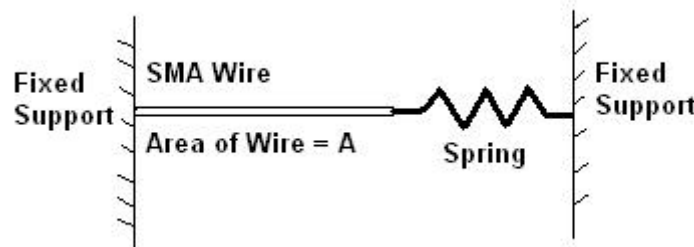
Assume:

Max Transformation Strain = H

Young's Modulus Austenite = E^A

Young's Modulus Martensite = E^M

Deflection = δ



- a. $\delta = H \cdot A \cdot E^A$
- b. $\delta = (k + (A \cdot E^A) / L)$
- c. $\delta = (H \cdot A \cdot E^A) / (k + (A \cdot E^A) / L)$
- d. None of the above

23. Which of the following is not a significant phenomena associated with SMA materials?

- a. Pseudoelasticity by transformation
- b. Pseudoelasticity by reorientation (Ferroelasticity)
- c. Dissipative interstitial reorientation
- d. The shape memory effect by reorientation
- e. Two-way shape memory effect

24. A transformation that is both adiabatic and isothermal can NOT occur at constant stress.

- a. True
- b. False

25. Which of the following is not a characteristic of the R Phase?

- a. It has around 25% memory strain
- b. It demonstrates shape memory
- c. It has almost no hysteresis
- d. It is extremely stable under repeat cycling