

# **MAEG5160 Design for Additive Manufacturing Final Examination**

Date: Dec. 04, 2020

Time Allowed: 30 mins (active on 9:30 AM – 11:00 AM) online

Student.I.D: \_\_\_\_\_

Seat No.: \_\_\_\_\_

Notes:

1. ALL questions should be answered (24 MC questions in total).
2. Put all your answers on the answer book / online provided.
3. Full mark is 30. Each question makes 1.25 mark towards the final score.
4. This is an open-book and open-note online examination.
5. Calculators are permitted.
6. Solve all problems using the answer book / online provided.
7. Write your student number clearly on the front page of your answer book.
8. Question papers should be returned after the examination.
9. Do not turn over this page until instructed to do so.
10. Unless otherwise specified, numerical answers should be either exact or correct to 3 significant figures.
11. For online exam, maximum (02) two attempts are allowed within the period of 1.5 hours (to avoid loss of internet connection). Only the HIGHEST attempt is counted, and each attempt is timed for 30 minutes. The remaining time is reserved for course evaluation.

Choose correct answers for the following questions:

1. (1.25 mark) Which one of the following options is NOT a category of the ISO/ASTM (2015) classification of additive manufacturing?

- (A) Binder Jetting                      (B) Material Extrusion  
(C) Selective Laser Melting              (D) Direct Energy Deposition

Correct answer: C

2. (1.25 mark) Which one of the following statements is TRUE?

- (A) Fused filament fabrication parts do not show significant anisotropy as its raw materials such as PLA and ABS do not show strong elastic anisotropy.  
(B) As selective laser sintering is a powder bed process, it does not have the overhang angle limit thanks to the powder bed support.  
(C) Vat Photopolymerisation does not allow overhang structure to be made, which is due to the lack of support by the liquid resin  
(D) None of the above

Correct answer: D

3. (1.25 mark) What is the most common powder size range for laser powder bed fusion?

- (A) 30-40  $\mu\text{m}$                       (B) 50-100  $\mu\text{m}$   
(C) 100-150  $\mu\text{m}$                       (D) 0-15  $\mu\text{m}$

Correct answer: A

4. (1.25 mark) The rotation angle for each hatch scan layer is?

- (A) 60°                      (B) 67°  
(C) 90°                      (D) 120°

Correct answer: B

5. (1.25 mark) Which one of the following is NOT part of the digital design for additive manufacturing workflow?

- (A) Embodiment design                      (B) Computer Aided Design  
(C) Slice geometry                      (D) None of the above

Correct answer: D

6. (1.25 mark) Which one of the following is NOT an element of the design optimization process?

- (A) Objective function                      (B) Constraints  
(C) Design variables                      (D) None of the above

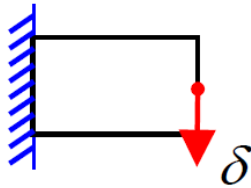
Correct answer: D

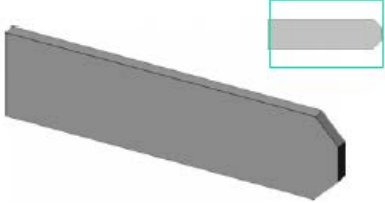
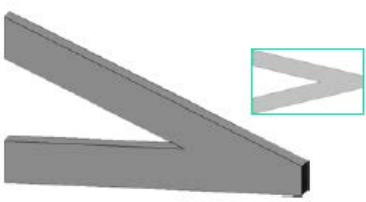
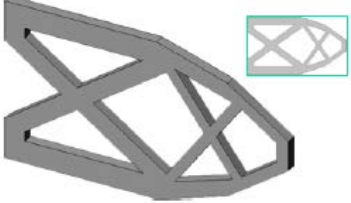
7. (1.25 mark) Which one of the following is NOT a type of the design optimization?

- (A) Size optimization
- (B) Structure optimization
- (C) Shape optimization
- (D) Topology optimization

Correct answer: B

8. (1.25 mark) Which one of the following designs gives the smallest displacement  $\delta$  at the load position on the right? (assuming the material volume is the same for all designs)



- (A) 1 bar 
- (B) 2 bars 
- (C) 17 bars 
- (D) both B and C

Correct answer: C

9. (1.25 mark) Adjoint method is usually applied to which step of the finite element based topological optimization?

- (A) Finite element analysis
- (B) Sensitivity analysis
- (C) Regularization (filtering)
- (D) Optimization (material re-distribution)

Correct answer: B

10. (1.25 mark) in the SIMP (Solid Isotropic Microstructure with Penalization for intermediate densities) method, what is the recommended  $p$  value range to achieve the “black-white” or so called “0-1” design?

- (A)  $p < 0$
- (B)  $0 < p < 1$
- (C)  $1 < p < 3$

(D)  $p > 3$

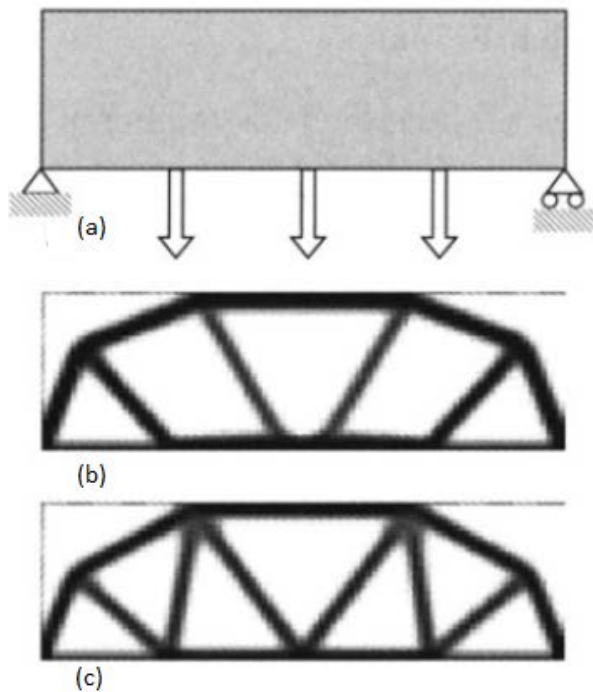
Correct answer: D

11. (1.25 mark) Which one of the following is NOT a common numerical issue/problem associated with SIMP method that is only numerically-based?

- (A) Appearance of checkerboards
- (B) Mesh-dependency of results
- (C) Non-unique solutions
- (D) None of the above

Correct answer: C

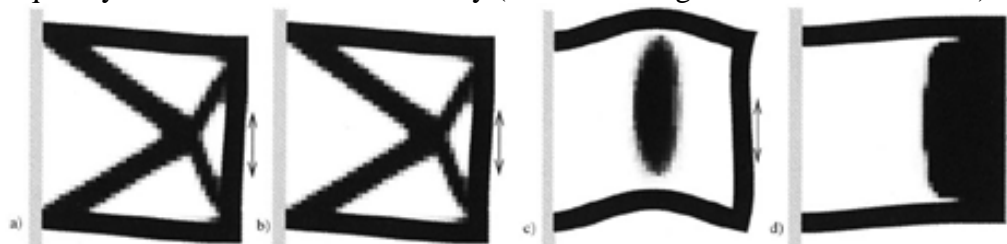
12. (1.25 mark) If (a) is the apparent boundary condition, what is the difference between topological optimization answer (b) and (c)?



- (A) Answer (b) is “all loads in one load case” and (c) is “multiple loading cases”
- (B) Answer (b) is “multiple loading cases” and (c) is “all loads in one load case”
- (C) Answers (b) and (c) are randomly generated, as the solution is not unique.
- (D) None of the above

Correct answer: A

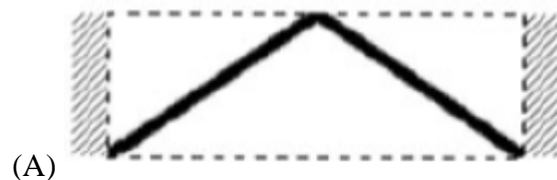
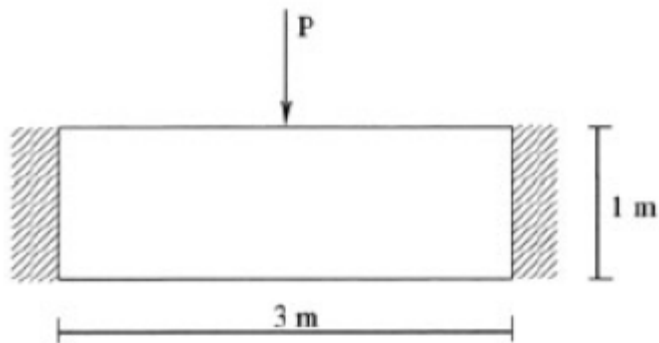
13. (1.25 mark) Which one of the following optimized topologies is for the highest driving frequency in the forced vibration study (load on the right side of the structure)?



(A) A (B) B (C) C (D) D

Correct answer: D

14. (1.25 mark) Given the boundary condition as below, which one of the following options is its optimized topology for large displacement and single load case (downward force)?



(D) None of the above

Correct answer: B

15. (1.25 mark) What kind of property the metamaterial below may possess?

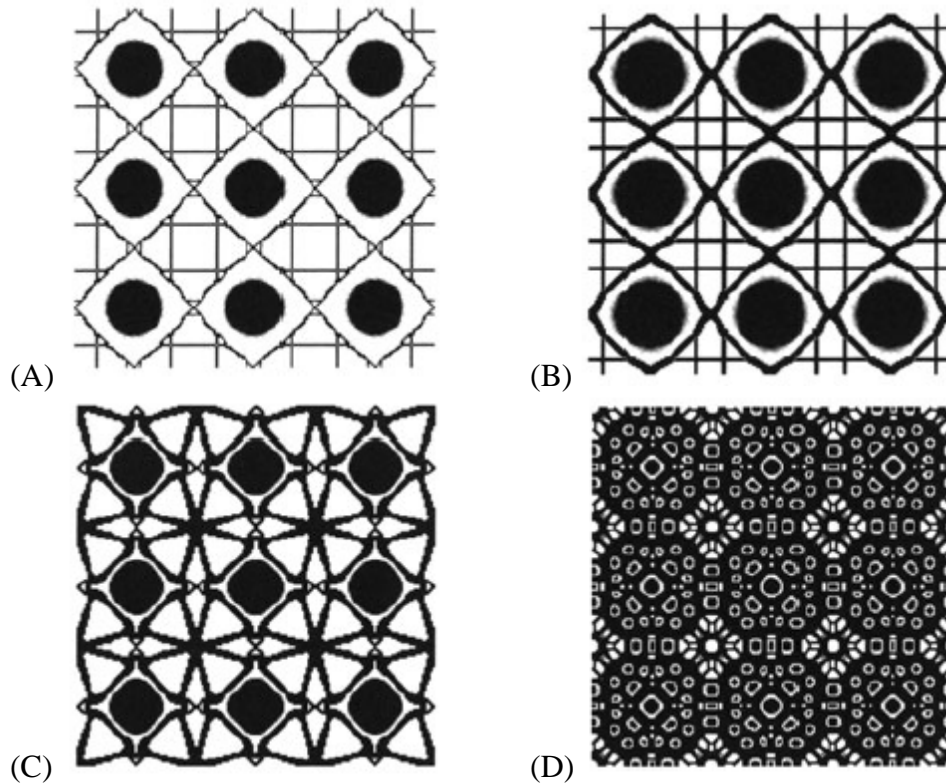


$\alpha=10$   $\alpha=1$

- (A) Perfect isotropy
- (B) Maximum theoretical bulk modulus
- (C) Negative Poisson's ratio
- (D) Negative thermal expansion coefficient

Correct answer: D

16. (1.25 mark) Which one of the following designs has the Poisson's ratio of 0?



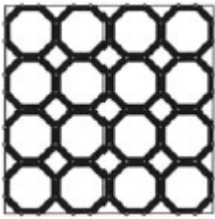
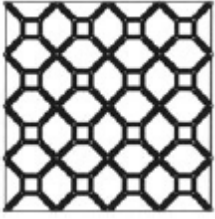
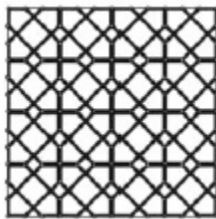
Correct answer: C

17. (1.25 mark) For the below shape options of single inclusions of void in a cell of a homogenized, periodic medium minimizing complementary energy, which is the result for principal stress ratios  $\sigma_{II}/\sigma_I = 0$  of a macroscopic stress field?



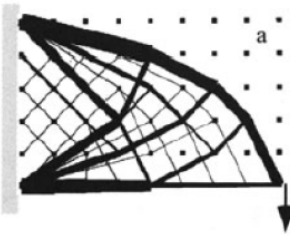
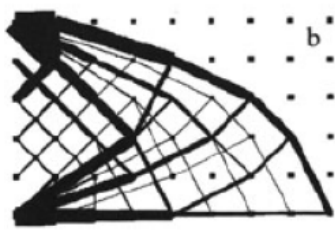

Correct answer: A

18. (1.25 mark) Which one of the following designs is an anisotropic metamaterial with Poisson's ratio = 1.0 for bi-axial equal-strain stretching?

- (A)  (B)  (C)  (D) All of the above

Correct answer: D

19. (1.25 mark) Which one of the following optimal truss topologies consider the highest self-weight loads? (boundary condition is given in A)

- (A)  (B)  (C) 
- (D) both B and C

Correct answer: C

20. (1.25 mark) Which one of the following is NOT a topological optimization method?

- (A) Solid isotropic material with penalization (SIMP) method  
(B) Bidirectional evolutionary structural optimization (BESO) method  
(C) Level-set method  
(D) None of the above

Correct answer: D

21. (1.25 mark) Which one of the following is NOT a parametric optimization method?

- (A) Brute force method  
(B) Ground-structure method  
(C) Nelder-Meade simplex method  
(D) Gradient method

Correct answer: B

22. (1.25 mark) Which one of the following is NOT an explicit method for Computer Aided Design (CAD)?

- (A) Voxel representation method  
(B) Constructive Solid Geometry method  
(C) Boundary representation method  
(D) None of the above

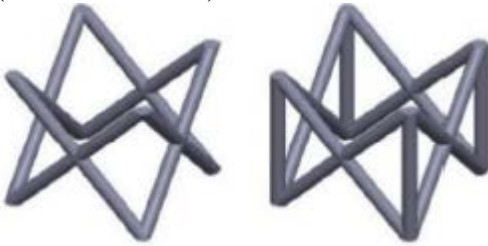
Correct answer: A

23. (1.25 mark) Which class of cellular materials does TPMS (Triply Periodic Minimal Surfaces) structures fabricated by additive manufacturing belong to?

- (A) Random, Open
- (B) Regular, Open
- (C) Random, Closed
- (D) Regular, Closed

Correct answer: B

24. (1.25 mark) What are the response type of the following two lattice unit cell designs (FCC and FCCZ)?



- (A) Bending-dominated, bending-dominated
- (B) Bending-dominated, stretch-dominated
- (C) Stretch-dominated, stretch-dominated
- (D) Stretch-dominated, bending-dominated

Correct answer: A

-THE END OF PAPER-