1. State the momentum principle in words.

2. State the momentum principle mathematically.

3. Aluminum has a density of $2.7 \text{ g/cm}^3$ and a molar mass of $27 \text{ g/mol}$ and copper has a density of $8.9 \text{ g/cm}^3$ and a molar mass of $64 \text{ g/mol}$. Which atom has a larger diameter, an aluminum atom or a copper atom?
   (a) aluminum  
   (b) copper  
   (c) every atom has the same diameter regardless of what element it is

4. You have two wires, a copper wire of radius $1 \times 10^{-4} \text{ m}$ and a copper wire of radius $1 \times 10^{-3} \text{ m}$. You hang each wire from a support, and you hang 1 kg from the end of each of the wires. Which wire will stretch the most from its original length?
   (a) the smaller radius wire  
   (b) the larger radius wire  
   (c) they will both stretch the same amount

5. The diameter of a gold atom is about $2.6 \times 10^{-10} \text{ m}$ and Young’s modulus for gold is about $7.8 \times 10^{10} \text{ N/m}^2$. What is the approximate stiffness of the interatomic bond between gold atoms if we model gold atoms as balls connected by springs?
   (a) $3.0 \times 10^{20} \text{ N/m}$  
   (b) $3.3 \times 10^{-19} \text{ N/m}$  
   (c) $3.0 \times 10^{-20} \text{ N/m}$  
   (d) $30 \text{ N/m}$  
   (e) $20 \text{ N/m}$

6. Suppose that in lab you measure the period $T$ of a 0.5 kg object attached to a spring. If you replace the spring with one that has twice the spring constant, the period will be
   (a) $2T$  
   (b) $(1/2)T$  
   (c) $\sqrt{2}T$  
   (d) $(1/\sqrt{2})T$  
   (e) $T$
7. You watch a physics student’s experiment and notice that the object attached to her spring travels from its lowest position to its highest position in about 1 second. What is the period of oscillation?

(a) 0.5 s
(b) 1 s
(c) 2 s
(d) 4 s
(e) It cannot be determined without knowing more information.

8. Springs used in the suspensions of light trucks have very high spring constants (stiffness). Suppose that 500 kg sits on one of these springs and the spring compresses 5.0 cm. What is the spring constant of the spring?

(a) 245 N/m
(b) 980 N/m
(c) $2.5 \times 10^3$ N/m
(d) $1.0 \times 10^4$ N/m
(e) $9.8 \times 10^4$ N/m

9. What would be the angular frequency of an oscillating spring-mass system if the mass is 500 kg and the spring constant is $4 \times 10^5$ N/m

(a) 28 rad/s
(b) 800 rad/s
(c) 178 rad/s
(d) 127 rad/s
(e) 4.5 rad/s

Questions 10–12: A position vs. time graph for an oscillating spring-mass system is shown in Figure 3.

10. What is the amplitude?

(a) 0.1 m
(b) 0.2 m
(c) 0.5 m
(d) 1 m
(e) 2 m

11. What is the period?

(a) 0.1 s
(b) 0.2 s
(c) 0.5 s
(d) 1 s
(e) 2 s

12. What is the phase?

(a) 0
(b) $\pi/2$
(c) $\pi$
(d) $3\pi/2$
13. A graph of strain vs. stretch for steel wire is shown in Figure 1. What is Young’s modulus for steel?

Questions 14–15: A graph of force vs. stretch for two different springs is shown in Figure 2.

14. Which spring is easier to stretch?

15. If you were to hang a 0.5 kg object on the end of Spring A, how far will it stretch from its unstretched position?

16. You decide to invent an exercise machine to help a High Point University cross-country runner build strength in his legs. It is a platform with two parallel springs attached between the platform and the wall. The athlete must push the platform with his legs. Since he probably won’t exert a force larger than 1000 N and you don’t want the springs to compress more than about 10 cm, what should be the spring constant of each spring?
Figure 1: Strain vs. stress for steel wire

Figure 2: Force vs. stretch for two different springs
Figure 3: x vs. t for oscillating spring-mass system

Answer Key for Exam A

1. The change in momentum of an object is equal to the net force on the object times the time interval during which the net force acts.

2. \[ \Delta \vec{p} = \vec{F}_{\text{net}} \Delta t \]

3. (a) 8. (e)
4. (b) 9. (a)
5. (e) 10. (a)
6. (d) 11. (e)
7. (c) 12. (d)

13. \( 20 \times 10^{10} \text{ N/m}^2 \)
14. Spring B, the one with the smaller slope (smaller stiffness).
15. \( F = 0.5(9.8) = 5N \) which corresponds to 0.2 m on the graph.
16. \( k = 500 \text{ N} / 0.1 \text{ m} = 5000 \text{ N/m} \)
Figure 4: Strain vs. stress for steel wire

Figure 5: Force vs. stretch for two different springs
Figure 6: $x$ vs. $t$ for oscillating spring-mass system