PHYSICS C
MECHANICS: SAMPLE EXAM 2
Time - 45 minutes
35 Questions

Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case.

1. The diagram below depicts a system in static equilibrium. What is the tension in chord A?

(A) $0.5mg \csc \theta$
(B) $mg \sec \theta$
(C) $mg \sin \theta$
(D) $\frac{mg}{\sin \theta}$
(E) $mg$

2. The diagram below shows a system in static equilibrium. The boom of length L is massless. The chord is attached to the midpoint of the boom. The tension in the chord is most nearly

(A) $0.7mg$
(B) $1.0mg$
(C) $1.4mg$
(D) $2.0mg$
(E) $2.8mg$

3. As shown below, a ball of mass m, moment of inertia I, and radius r rolls down an inclined plane of slope angle $\theta$ without slipping. The acceleration of the ball is

(A) $\frac{mgr^2 \sin \theta}{1 + mr^2}$
(B) $\frac{mgr^2 \cos \theta}{1 - mr^2}$
(C) $\frac{mgr^2}{I}$
(D) $g \sin \theta$
(E) $g$

4. An object falls a distance $h$ with no air resistance. The instantaneous power with which gravity acts on the object is

I. $mgh$
II. $mgv$, where $v$ is the instantaneous speed of the object
III. $\frac{dW}{dt}$, where $W$ is work and $t$ is time

(A) I only
(B) II only
(C) III only
(D) I and II
(E) II and III
Questions 5 - 7
An object of mass \( m \) moves in uniform circular motion of speed \( v \) and radius \( r \), as shown below.

5. Which of the following remains constant?
   I. the angular velocity of the object
   II. the angular momentum vector of the object
   III. the linear momentum vector of the object

(A) I only  
(B) II only  
(C) III only  
(D) I and II  
(E) I and III

6. If the graph below refers to the object in uniform circular motion, what does the vertical axis of the graph likely represent?

\[ \text{time} \]

I. the tangential speed of the object  
II. the angular acceleration of the object  
III. the displacement of the object in one dimension

(A) I only  
(B) II only  
(C) III only  
(D) I and II  
(E) II and III

7. The centripetal acceleration of the object is
   I. directly proportional to \( m \)  
   II. inversely proportional to \( r \)  
   III. directly proportional to \( v \)

(A) I only  
(B) II only  
(C) III only  
(D) I and II only  
(E) I, II, and III

Questions 8 - 10
A ball of mass \( m \) and negligible moment of inertia rolls down the ramp shown from zero initial velocity at point A, around the loop and through point B, and to point C where it strikes a fixed spring of spring constant \( k \). Assume there are no nonconservative forces present.

8. The kinetic energy of the ball at point B is

(A) 0  
(B) \( mgh \)  
(C) \( mg(h+r) \)  
(D) \( mgH \)  
(E) \( mg(H - 2r) \)

9. The distance the spring at C is compressed by the ball is

(A) \( \sqrt{\frac{mg}{k}} \)  
(B) \( \sqrt{\frac{k}{m}} \)  
(C) \( \sqrt{\frac{mgH}{k}} \)  
(D) \( \sqrt{\frac{2mg(h)}{k}} \)  
(E) \( \sqrt{\frac{2mg(H + h - r)}{k}} \)

10. If the ball is not to fall off the ramp as it approaches point B, which of the following conditions must hold?

   I. the centripetal force at point B must be zero  
   II. the centripetal force at B must be at least as great as \( mg \)  
   III. \( F \) must be at least as great as \( 2.5r \)

(A) I only  
(B) II only  
(C) III only  
(D) I and III  
(E) II and III
Questions 11 and 12
As shown in the diagram below, block A is held on a frictionless inclined plane of slope angle \( \theta \) and is attached by a massless chord running over a massless, frictionless pulley to block B. Block B hangs freely. Both blocks have identical mass \( m \).

11. When block A is released, the acceleration of the system is

(A) \( 0.5g(1 - \sin \theta) \)
(B) \( 0.5g(1 - \cos \theta) \)
(C) \( g \sin \theta \)
(D) \( g (1 + \sin \theta) \)
(E) \( g \)

12. When block A is released, the tension in the chord is

(A) \( mg \)
(B) \( 2mg \)
(C) \( 0.5mg(1 + \sin \theta) \)
(D) \( mg(1 - \cos \theta) \)
(E) \( 0 \)

13. An object of mass \( m \) accelerates from speed \( v \) to speed \( 2v \). The work done on the object in this process is

(A) \( 0 \)
(B) \( 0.5mv^2 \)
(C) \( mv^2 \)
(D) \( 1.5mv^2 \)
(E) \( 2.0mv^2 \)

14. A force \( F = AT \) acts on an object from time \( t = 0 \) to time \( t = T \), where \( A \) is a constant. The impulse on the object over this period is

(A) \( A \)
(B) \( AT \)
(C) \( 0.5AT \)
(D) \( 0.5AT^2 \)
(E) \( AT^2 \)

15. A train consists of a locomotive of mass \( 2M \) followed by three freight cars of mass \( M \) and a caboose of mass \( \frac{M}{2} \) as shown below. The locomotive pulls the train (and itself) with a force \( F \), giving it a uniform acceleration. Assuming there is no frictional drag on the train, the net force acting on the caboose is

(A) \( 0 \)
(B) \( \frac{F}{11} \)
(C) \( \frac{F}{4} \)
(D) \( \frac{F}{2} \)
(E) \( F \)

16. A hard rubber ball of mass \( m \) hits a wall squarely at speed \( v \), as shown below. It rebounds 180 degrees from its original direction, also at speed \( v \). The impulse that the wall gives to the ball is

(A) \( \frac{mv}{4} \)
(B) \( \frac{mv}{2} \)
(C) \( mv \)
(D) \( 2mv \)
(E) \( 4mv \)
Questions 17 and 18
As diagrammed below, a block of mass $m$ slides on a frictionless surface at speed $v$. It makes an inelastic collision with a block of mass $2m$, initially at rest.

17. The speed of the first block after the collision is

(A) $-3v$
(B) $-v$
(C) $\frac{v}{3}$
(D) $\frac{v}{2}$
(E) $v$

18. The kinetic energy lost in the collision is most nearly

(A) 0
(B) $0.3mv^2$
(C) $0.5mv^2$
(D) $mv^2$
(E) $2mv^2$

19. A wheel of radius $R$ rotates at angular velocity $\omega$. A belt connects this wheel to another wheel of radius $2R$ with no slippage, as shown below. The angular velocity of the second wheel is

(A) $\frac{\omega}{4}$
(B) $\frac{\omega}{2}$
(C) $\omega$
(D) $2\omega$
(E) $4\omega$

20. A wheel of moment of inertia $I$ is at rest. A torque acts on the wheel to bring it up to angular velocity $\omega$ over an angle $\theta$, as shown below. The magnitude of the torque on the wheel is

(A) $\frac{\theta I\omega}{\theta}$
(B) $\frac{I\omega^2}{\theta}$
(C) $I\theta\omega^2$
(D) $\frac{I\theta^2}{2\theta}$
(E) $0.5I\omega^2$

21. A block oscillates at the end of a spring, as shown below. If there is a nonzero coefficient of friction between the block and the table, the oscillatory motion will damp out until the spring comes to rest. During this process,

I. the frequency of the oscillations decreases
II. the amplitude of the oscillations decreases
III. the period of the oscillations increases

(A) I only
(B) II only
(C) III only
(D) I and II
(E) I and III
Questions 22 - 24
A planet is in a circular orbit about a star of mass M. The radius of the orbit is R. The planet may be considered to be a point of mass m. Refer to the diagram below.

22. The angular momentum of the planet in its orbit is proportional to
   (A) \( MmR \)
   (B) \( \frac{Mm}{R} \)
   (C) \( m\sqrt{\frac{M}{R}} \)
   (D) \( m\sqrt{MR} \)
   (E) \( Mm \)

23. If G represents the Universal Gravitational Constant, the kinetic energy of the planet is equal to
   (A) \( \frac{GMm}{2R} \)
   (B) \( \frac{GMm}{R} \)
   (C) 0
   (D) \( GMR^2 \)
   (E) \( mR^2 \)

24. The gravitational force between the planet and the star is directly proportional to
   I. \( \frac{M}{R} \)
   II. \( \frac{m}{R} \)
   III. \( \frac{Mm}{R^2} \)
   (A) I only
   (B) II only
   (C) III only
   (D) I and II only
   (E) I, II, and III

25. The acceleration due to gravity on the surface of the moon is one-sixth of what it is on the surface of the earth. A pendulum has period \( T \) on the earth. Its period on the moon is most nearly
   (A) 0.17\( T \)
   (B) 0.41\( T \)
   (C) 1.00\( T \)
   (D) 2.45\( T \)
   (E) 6.00\( T \)

Questions 26 and 27
An object is in simple harmonic motion of period \( T \) and amplitude \( A \).

26. The maximum acceleration of the object is most nearly
   (A) \( A \)
   (B) \( \frac{A}{T} \)
   (C) \( \frac{A}{T^2} \)
   (D) \( \frac{6.28A}{T} \)
   (E) \( \frac{29.5A}{T^2} \)

27. The kinetic energy of the object is maximum when
   I. the object is at the equilibrium position
   II. the object is at its maximum displacement from equilibrium
   III. the potential energy of the object is at its maximum
   (A) I only
   (B) II only
   (C) III only
   (D) I and II
   (E) II and III
Questions 28 - 30
Refer to the diagram below. The object shown consists of four point masses, each of identical mass m, fixed to the corners of a square by four rigid, massless rods. The object is free to rotate with period T about an axis which passes through objects C and D, as indicated. The length of one side of the square is L.

![Diagram of a square with masses at the corners and an axis passing through C and D.]

28. The angular momentum of the object as it rotates is most nearly

(A) \( \frac{6.28ML^2}{T} \)

(B) \( \frac{12.6ML^2}{T} \)

(C) \( \frac{39.5ML^2}{T} \)

(D) \( \frac{ML}{T} \)

(E) \( \frac{39.5ML}{T} \)

29. The kinetic energy of the object as it rotates is

(A) 0

(B) \( 0.5M \left( \frac{1}{T} \right)^2 \)

(C) \( 6.28M \left( \frac{1}{T} \right)^2 \)

(D) \( 12.6M \left( \frac{1}{T} \right)^2 \)

(E) \( 39.5M \left( \frac{1}{T} \right)^2 \)

30. The moment of inertia of the object would be maximized by placing the axis of rotation

(A) perpendicular to the plane of the square and through the center

(B) along a diagonal of the square, through objects A and D

(C) perpendicular to the plane of the square and through object A

(D) right where it is, through objects C and D

(E) through objects A and B

Questions 31 and 32
A cannon of mass M is initially at rest but free to move on its wheels, as shown below. It fires a shell of mass m horizontally at speed v.

![Diagram of a cannon firing a shell.]

31. The recoil speed of the cannon is

(A) 0

(B) \( \frac{mv}{M} \)

(C) \( \frac{Mv}{m} \)

(D) \( \frac{mv}{M+m} \)

(E) \( \frac{mv}{M-m} \)

32. The change in kinetic energy of the system consisting of the cannon and the shell is

I. positive

II. negative

III. equal to the sum of the kinetic energy of the cannon and the kinetic energy of the shell after firing

(A) I only

(B) II only

(C) III only

(D) I and II

(E) II and III
33. Block A and block B in the figure below have the same mass. Block A rests on a table and is connected by a massless chord which passes over massless, frictionless pulleys to block B, which hangs freely. For the system to be in static equilibrium, which conditions must exist?

I. the coefficient of friction between block A and the table must be zero
II. the normal force the table exerts on block A must be zero
III. the frictional force on block A must be equal to the tension in the horizontal portion of the chord

Questions 34 and 35
A block of mass 2 kg slides down an inclined plane of slope angle 30 degrees, as shown below. The coefficient of friction between the block and the plane is 0.2 and the plane is 1 m high at its highest point.

34. The acceleration of the block is most nearly

(A) 3.2 m/s²
(B) 4.9 m/s²
(C) 6.6 m/s²
(D) 7.5 m/s²
(E) 9.5 m/s²

35. The time it takes the block to slide from the top to the bottom of the plane is most nearly

(A) 0.6 s
(B) 0.8 s
(C) 1.1 s
(D) 3.1 s
(E) 5.2 s
Part 1 Answer Sheet

Place the best answer to each question in the space provided.

1. A
2. E
3. A
4. E
5. D
6. C
7. B
8. E
9. D
10. E
11. A
12. C
13. D
14. D
15. B
16. D
17. C
18. B
19. B
20. D
21. B
22. D
23. A
24. D
25. D
26. E
27. A
28. B
29. E
30. C
31. B
32. D
33. C
34. A
35. C

Number correct _______ x 1 = _______
Number left blank _______ x 1 = _______
Number incorrect _______ x -.25 = _______

Score (out of 35) _______

Grade _______ AP Score _______