Diagnostic Test

Do not use a calculator. To simplify numerical calculations, use $g = 10\ m/s^2$.

PART A

Directions: In this section of the exam, the same lettered choices are used to answer several questions. Each group of questions is preceded by five lettered choices. When answering questions in each group, select the best answer from the available choices and fill in the corresponding bubble on the answer sheet. Each possible answer may be used once, more than once, or not at all.

Questions 1–3

(A) Amplitude
(B) Frequency
(C) Resonance
(D) Wave speed
(E) Oscillation

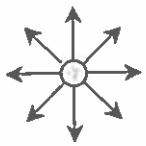
1. The brightness of light and the volume of sound are associated with which wave characteristic?

2. Which wave property is controlled by the medium that the wave propagated through?

3. Which wave property remains constant when light waves enter a medium that has a greater density?

Questions 4–6 refer to the following field diagrams.

(A)



(B)

(C)

(D)

(E)

4. Which diagram correctly depicts a uniform magnetic field?

5. Which diagram correctly depicts the magnetic field of a wire carrying a current into and perpendicular to the page?

6. Which diagram correctly depicts the electric field surrounding an electron?

Questions 7–8

(A) Albert Einstein
(B) Albert Michelson
(C) James Maxwell
(D) Ernest Rutherford
(E) J. J. Thomson

7. Which scientist suggested that light could be thought of as packets of energy and that the exact quantity of energy could be determined by the equation $E = hf$?

8. Which scientist determined that the atom consisted mostly of empty space with a small, dense, positive nucleus?

Questions 9–11

(A) Coulomb's law
(B) Faraday's law
(C) First law of thermodynamics
(D) Lenz's law
(E) Second law of thermodynamics

9. The change in internal energy of a system is equal to the energy transferred into or out of the system by work and/or heat.

10. This law describes the direction an induced current must flow so that the induced magnetic field opposes the change in flux of the original magnetic field.

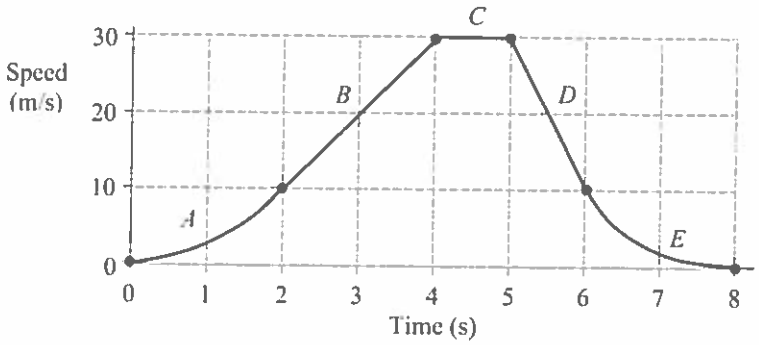
11. The entropy of a system always increases until the system reaches equilibrium.

PART B

Directions: This section of the exam consists of questions or incomplete statements followed by five possible answers or completions. Select the best answer or completion, and fill in the corresponding bubble on the answer sheet.

Questions 12–14

The motion of an object is depicted in the following speed-time graph.



12. Determine the magnitude of acceleration during interval *B*, from 2 seconds to 4 seconds.

(A) 0 m/s^2
(B) 10 m/s^2
(C) 15 m/s^2
(D) 20 m/s^2
(E) 40 m/s^2

13. During which interval(s) is the object moving at a constant velocity?

(A) *A* only
(B) *B* only
(C) *C* only
(D) Both *A* and *E*
(E) Both *B* and *D*

14. During which interval did the object travel the farthest?

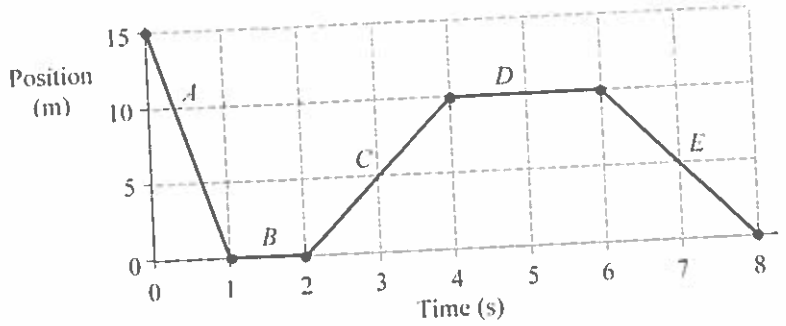
(A) *A*
(B) *B*
(C) *C*
(D) *D*
(E) *E*

15. An object is accelerating. Which of the following is NOT possible?

(A) The speed of the object may be constant.
(B) The magnitude of the object's velocity may be constant.
(C) The velocity of the object may be constant.
(D) The object may be turning.
(E) The magnitude of the force acting on the object is constant.

Questions 16–17

The motion of an object is depicted in the following position-time graph.



16. During which interval(s) is the magnitude of the object's velocity decreasing?

(A) *A* only
(B) *B* only
(C) *E* only
(D) *A* and *E* only
(E) None of these

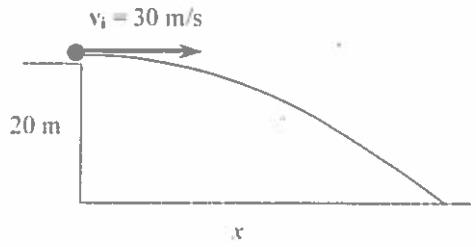
17. During which interval does the object have the greatest speed?

(A) *A*
(B) *B*
(C) *C*
(D) *D*
(E) *E*

---

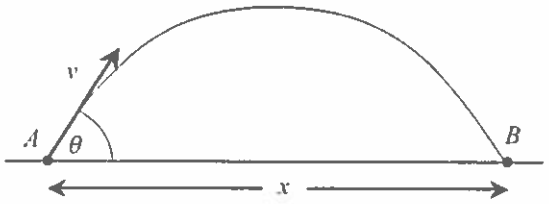
18. An object initially at rest uniformly accelerates for t seconds and moves distance x. An identical object that has twice the force applied to it during the same time, t, will move a distance

(A) $\frac{1}{2}x$
(B) x
(C) $\sqrt{2}(x)$
(D) $2x$
(E) $4x$



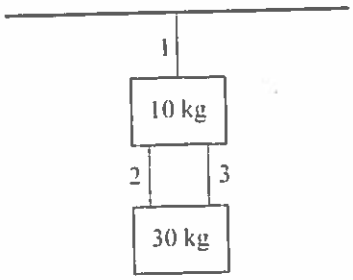
19. A ball is thrown horizontally at 30 meters per second from the top of a 20-meter-tall platform, as shown above. Determine the horizontal distance traveled by the ball.

(A) 10 m
(B) 20 m
(C) 40 m
(D) 50 m
(E) 60 m



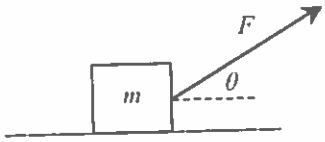
20. The diagram above depicts a projectile launched from point A with a speed v at an angle of θ above the horizontal. The projectile hits the ground at point B, achieving a final range of x. The total time of flight from point A to point B is t seconds. Determine the speed of the projectile at point B.

(A) zero
(B) v
(C) $\frac{1}{2}v$
(D) $v \cos \theta$
(E) $v \sin \theta$



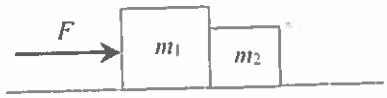
21. Two masses, 10 kilograms and 30 kilograms, are suspended by massless ropes from the ceiling, as shown in the diagram above. Determine the tension in rope 3.

(A) 100 N
(B) 150 N
(C) 200 N
(D) 300 N
(E) 400 N



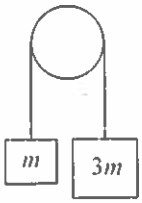
22. As shown in the figure above, mass m is pulled along a rough horizontal surface by force F, acting at an angle θ measured from the surface. The resulting motion is constant velocity. Which statement below is true?

(A) The weight, W, of the object is equal to the normal force, N.
(B) The weight, W, of the object is less than the normal force, N.
(C) The force of friction, f, is equal to the applied force, F.
(D) The force of friction, f, is less than the applied force, F.
(E) The force of friction, f, is greater than the applied force, F.



23. A force, $F = 12$ newtons, pushes two masses, $m_1 = 3$ kilograms and $m_2 = 1$ kilogram, horizontally along a frictionless surface, as shown in the diagram above. Determine the acceleration of mass m_2.

(A) 1 m/s^2
(B) 2 m/s^2
(C) 3 m/s^2
(D) 4 m/s^2
(E) 12 m/s^2



24. Masses m and $3m$ are connected by a string, which is draped over a pulley, as shown in the diagram above. The masses are released from rest. Determine the magnitude of acceleration of mass m.

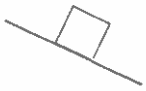
(A) $\frac{g}{4}$
(B) $\frac{g}{3}$
(C) $\frac{g}{2}$
(D) g
(E) $2g$

25. At $t = 0$ seconds, a force, $F_1 = 10$ newtons, acting in the $+x$-direction is applied to a 5-kilogram mass that is initially at rest. At $t = 2$ seconds, a new force is added to the first force. The new force, $F_2 = 10$ newtons, acts in the $-x$-direction. Determine the acceleration of the object at $t = 5$ seconds while both forces continue to be applied.

(A) zero
(B) 1 m/s^2
(C) 2 m/s^2
(D) 4 m/s^2
(E) 5 m/s^2

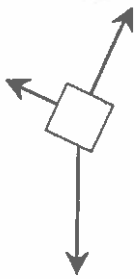
26. A 50-kilogram person stands on a scale in an elevator that is accelerating upward at 1 meter per second squared. What is the apparent weight of the person?

(A) zero
(B) 50 N
(C) 450 N
(D) 500 N
(E) 550 N



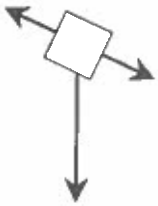
27. A mass remains at rest on an incline, as shown above. Which free-body diagram is correct?

(A)



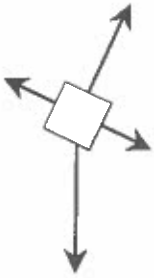
(B)

(C)



(D)

(E)

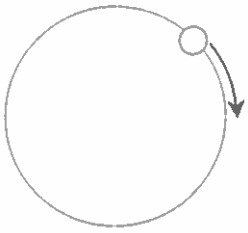


28. An object in uniform circular motion with a radius of 20 meters has a frequency of 0.10 hertz. Determine the speed of the object.

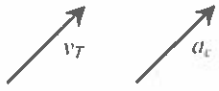
(A) π m/s
(B) 2π m/s
(C) 4π m/s
(D) 8π m/s
(E) 16π m/s

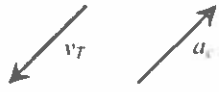
29. What is the maximum speed possible that a car can turn on a road with a radius of 5 meters and a coefficient of friction of 0.5 without slipping?

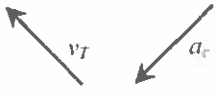
(A) 1 m/s
(B) 5 m/s
(C) 10 m/s
(D) 25 m/s
(E) 30 m/s

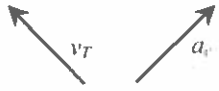


30. The object in the diagram above is in uniform circular motion. Which vectors show the tangential velocity and centripetal acceleration for the object at the instant diagrammed?

(A) 

(B) 

(C) 

(D) 

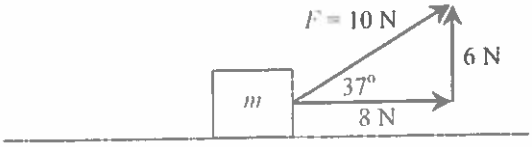
(E) 

31. A roller coaster needs to complete a vertical loop that has a radius of 14.4 meters. What must the coaster's minimum speed be at the top of the loop?

(A) 5 m/s
(B) 7 m/s
(C) 10 m/s
(D) 12 m/s
(E) 14 m/s

Questions 32–33

In the figure below a 10-newton force, F, is applied at a 37° angle with respect to the horizontal to a mass, m. The mass is pulled horizontally to the right at constant velocity along a rough surface. Force F and its components are shown in the diagram.

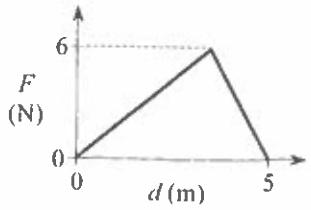


32. Determine the work required to move the mass a distance of 5.0-meters horizontally.

(A) zero
(B) 30 J
(C) 40 J
(D) 50 J
(E) 100 J

33. Determine the net work done on the object during the 5.0 meter motion.

(A) zero
(B) 30 J
(C) 40 J
(D) 50 J
(E) 100 J

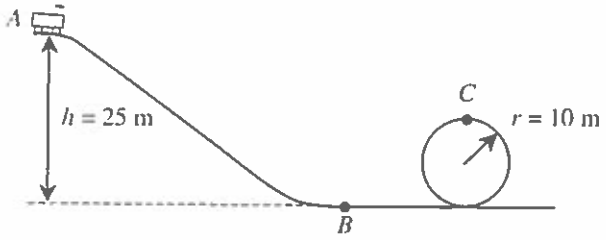


34. A variable force acts on a 2.0-kilogram mass, displacing the mass 5.0 meters. The force and displacement are graphed above. Determine the work done on the mass by the variable force.

(A) 5 J
(B) 10 J
(C) 15 J
(D) 20 J
(E) 30 J

Questions 35–36

A 50-kilogram roller coaster car is initially at rest at the top of a 25-meter-high hill. When it is released, the car rolls down the hill and passes through a loop that has a radius of 10 meters.



35. Determine the speed of the roller coaster when it reaches point *B* at the bottom of the hill.

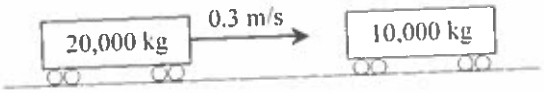
(A) $\sqrt{20}$ m/s
(B) $5\sqrt{20}$ m/s
(C) $15\sqrt{20}$ m/s
(D) $20\sqrt{20}$ m/s
(E) $25\sqrt{20}$ m/s

36. How much work is done against gravity as the roller coaster car moves from point B to point C?

(A) 1,000 J
(B) 2,500 J
(C) 5,000 J
(D) 10,000 J
(E) 20,000 J

37. Stretching a spring a distance of x requires a force of F. In the process, potential energy, U, is stored in the spring. If that same spring is stretched so that it stores $4U$ of potential energy, how far is the spring stretched?

(A) $2x$
(B) $4x$
(C) x^2
(D) x^4
(E) $2x^2$



38. As shown in the diagram above, a 20,000-kilogram railroad freight car is moving at 0.3 meter per second when it strikes and couples with a 10,000-kilogram freight car that is initially at rest. What is the resulting speed of the railroad freight cars after the collision?

(A) 0.1 m/s
(B) 0.2 m/s
(C) 0.3 m/s
(D) 0.6 m/s
(E) 0.9 m/s

39. Which of the following quantities is NOT conserved in a perfectly elastic collision?

(A) Velocity only
(B) Linear momentum only
(C) Kinetic energy only
(D) Both A and C
(E) Both B and C

1 – 39
1st