Write clearly in the space provided on this Answer Sheet the letter which you believe to be the best answer to each question found on the following pages. Only answers on this page will be graded.

Each question is worth 5 points.

1) A____ 9) A____ 17) C____
2) C____ 10) C____ 18) B____
3) B____ 11) D____ 19) B____
4) C____ 12) A____ 20) A____
5) B____ 13) C____ 21) C____
6) B____ 14) D____ 22) A____
7) C____ 15) D____ 23) A____
8) D____ 16) D____ 24) ABCD____

Starting Equations:

\[ x = x_i + v_{ix} \Delta t + \frac{1}{2} a_x (\Delta t)^2 \quad v_x = v_{ix} + a_x \Delta t \quad v_x^2 = v_{ix}^2 + 2 a_x (x - x_i) \]

\[ y = y_i + v_{iy} \Delta t + \frac{1}{2} a_y (\Delta t)^2 \quad v_y = v_{iy} + a_y \Delta t \quad v_y^2 = v_{iy}^2 + 2 a_y (y - y_i) \]

\[ \sum F_x = m a_x \quad \sum F_y = m a_y \quad f_s \leq \mu_s N \quad f_k = \mu_k N \quad g = 9.8 \text{m/s}^2 \]

\[ a_c = \frac{v^2}{R} \quad v = \frac{2 \pi R}{T} = \omega R \quad \omega = 2 \pi f = \frac{2 \pi}{T} \quad F_G = \frac{G m M}{r^2} \quad F_S = k \Delta x \]

\[ \tau = r F \sin \theta \quad \sum \tau = I \alpha \quad v = \omega r \quad a = \alpha r \quad I = \sum_i m_i r_i^2 \quad L = I \omega \]

\[ \vec{p} = m \vec{v} \quad \vec{J} = \vec{F}_{avg} \Delta t \quad \vec{P}_f - \vec{P}_i = \vec{J}_{ext} \quad W = F d \cos \theta \quad \Delta E = W \]

\[ K = \frac{1}{2} m v^2 \quad U_{grav} = mgy \quad U_{spring} = \frac{1}{2} k x^2 \quad \Delta E_{th} = f_s \Delta x \quad P = W/\Delta t = F v \]
For all problems: neglect air resistance.

1. A particle is moving along a straight line. The slope of the velocity vs time graph at a particular time gives the particle’s
A) instantaneous acceleration at that time B) average speed
C) position at that time D) displacement

2. The motion of an object is described by the x-t-diagram at the right. Which of the following is true?
A) The object moves to the left at A.
B) The object has its highest speed at B.
C) The object moves to the left at C.
D) The object stops at D.

3. A particle is moving in a circle with constant speed. The acceleration is
A) zero B) towards the center of the circle C) tangent to the circle
D) away from the center of the circle

4. An airplane flies horizontally with a speed \( V_0 \) at a height \( H \) above the ground. What time does it take for a package to fall to the ground after it is released from the plane?
A) \( H / V_0 \) B) \( 2V_0 / g \) C) \( (2H / g)^{1/2} \) D) \( V_0 + (V_0^2 + 2gH)^{1/2} / g \)

5. For the package in question 4: how far did the package move \textbf{horizontally} during time \( T \) after it is released?
A) \( H \) B) \( V_0 T \) C) \( V_0 T - gT^2 / 2 \) D) \( (H^2 + V_0^2 T^2)^{1/2} \)

6. A particle is moving with velocity \( V \). At a particular instant, it experiences an acceleration \( a \) as shown in the figure. We know that the particle is:
A) only speeding up B) slowing down and changing direction of motion.
C) only slowing down D) speeding up and changing direction of motion.

7. You are standing on a scale in an elevator. In which of the following situations does the scale show less than your actual weight? The elevator is moving…
A)…upwards at constant speed B) …upwards and speeding up
C) …downwards and speeding up D)… downwards and slowing down

8. A particle rotates in a circle with centripetal acceleration \( a \). If the period is halved without changing the radius, the new acceleration will be
A) \( \frac{1}{4} a \) B) \( \frac{1}{2} a \) C) \( 2a \) D) \( 4a \)
9. Block A is on a frictionless horizontal surface. An identical block B is on top of block A. A constant horizontal force of magnitude P is exerted on block A, pushing it to the right. Block B rides on block A without slipping. The frictional force on block B is:
A) static, to the right  
B) static, to the left  
C) kinetic, to the right  
D) zero

10. For the blocks in problem 9, which two forces are an action-reaction pair?
A) the weight of block A and the normal force acting on block B  
B) the pushing force on block A and the force of friction on block B  
C) the force of friction A exerts on B and the force of friction B exerts on A  
D) there is no action-reaction pair, because the acceleration is not zero

11. A crate of mass $M$ is pushed across a frictionless horizontal floor by a force $P$ that makes an angle $\theta$ with the horizontal. The normal force equals:
A) $P \sin \theta$  
B) $Mg$  
C) $P + Mg$  
D) $P \sin \theta + Mg$

12. The total force acting on an object is constant. Which is true?
A) The magnitude of the acceleration is constant.  
B) The direction of the velocity remains constant.  
C) The speed of the object remains constant.  
D) At no instant during its motion can the object have zero speed.

13. Mass $m$ on a frictionless incline is connected to mass $M$ by a rope that runs over a massless, frictionless pulley. $M$ moves upwards at constant speed. We know that the tension $T$ in the rope:
A) $T=0$  
B) $T<Mg$  
C) $T=Mg$  
D) $T>Mg$

14. The mass of a certain planet is two times the mass of the Earth. Its radius is twice the radius of the earth. The free fall acceleration on this planet is:
A) $4g$  
B) $2g$  
C) $g$  
D) $\frac{1}{2}g$

15. If the mass of the moon were doubled but it stayed in its present orbit, the orbital speed would
A) halve.  
B) double.  
C) quadruple.  
D) stay the same.

16. A 3 kg weight is suspended from a spring, stretching it by 3 cm. The spring constant of the spring is about
A) 1 N/m  
B) 3 N/cm  
C) 30 N/cm  
D) 10 N/cm

17. A spring is compressed a certain distance and shoots out a ball with a certain speed. In order to double the launch speed, the distance by which the spring is compressed must be
A) reduced by factor of four  
B) halved  
C) doubled  
D) quadrupled
18. Four forces are acting on a beam that can rotate about an axle through its center, as shown in the figure. Which of the forces produce a non-zero torque with respect to the axle?
A) all of them  B) 1 and 2
C) 1, 2 and 3  D) 1, 2, and 4

19. A ball of mass $m$ hits the horizontal floor with speed $v$ and bounces off the floor with the same speed. The angle of incidence equals the angle of rebound. The impulse delivered to the ball by the floor is
A) zero.  B) in the $y$-direction.
C) equal to $m\vec{v}$.  D) in the $x$-direction.

20. A car of mass $M$ that is traveling West collides with a truck of mass $2M$ that is traveling North. The fused wreckage moves with speed $V$ at an angle $\theta$ West of North as shown in the figure. The initial speed of the car just before the collision was:
A) $3V\sin \theta$  B) $3V\cos \theta$
C) $\frac{1}{3}V\sin \theta$  D) $\frac{2}{3}V\cos \theta$

21. The work done by a force on an object is zero. This is the case if the force is
A) constant.  B) parallel to the displacement.  C) perpendicular to the displacement.

22. Two air track carts of masses $M$ and $4M$, respectively, compress a spring. The system is released from rest. The spring drops to the ground after it has expanded. The heavy cart acquires a final speed $v$. What is the final speed of the lighter cart?
A) $4v$  B) $\frac{1}{4}v$  C) $2v$
D) can’t determine without knowing spring constant and initial compression

23. A block of mass $M$ sits on a vertical spring of force constant $k$ that is compressed a distance $S$ from its equilibrium length. The block is then released from rest and it shoots up, leaving the spring behind. The maximum height above the starting position is
A) $kS^2 / 2Mg$  B) $S$  C) $\frac{1}{2}kS^2$  D) $(kS^2 / M + 2gH)^{\frac{1}{2}}$

24. If you looked at the old Final, you saw that there was a free question at the end. Did you expect you would get one too?
A) no  B) yes  C) expect-no, but I hoped  D) Is this the free question?