50. A hoop rolls with constant velocity and without sliding along level ground. Its rotation kinetic energy is:

A) half its translational kinetic energy
B) the same as its translational kinetic energy
C) twice its translational kinetic energy
D) four times its translational kinetic energy
E) one-third its translational kinetic energy

$KE = \frac{1}{2} mv^2$

$\omega = V/R$

$KE_R = \frac{1}{2} I \omega^2$

$= \frac{1}{2} M\cancel{R^2} \cdot \frac{V^2}{\cancel{R^2}}$

$= \frac{1}{2} MV^2$

42. A watt per hour is a unit of:
A) energy
B) power
C) force
D) acceleration
E) none of these

$\cancel{E=Pt}$

$P = \frac{E}{t} \rightarrow \frac{J}{s} \rightarrow \frac{kg\frac{m^2}{s^2}}{s^2} \rightarrow kg\frac{m^2}{s^3}$

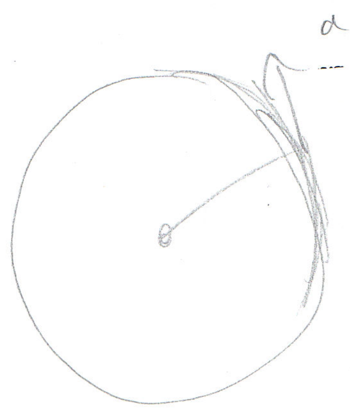
43. In planetary motion the line from the star to the planet sweeps out equal areas in equal times. This is a direct consequence of:
A) the conservation of energy
B) the conservation of momentum
C) the conservation of angular momentum
D) the conservation of mass
E) none of the above

44. An object at the surface of Earth (at a distance *R* from the center of Earth) weighs 90 N. Its weight at a distance 3*R* from the center of Earth is:
A) 10 N
B) 30 N
C) 90 N
D) 270 N
E) 810 N

$F_g \propto \frac{1}{R^2}$

45. For a wheel spinning on an axis through its center, the ratio of the radial acceleration of a point on the rim to the radial acceleration of a point halfway between the center and the rim is:
A) 1
B) 2
C) 1/2
D) 4
E) 1/4

$a_c = \frac{mv^2}{R}$



33. The displacement of a mass oscillating on a spring is given by $x(t) = x_m\cos(\omega t + \phi)$. If the initial displacement is zero and the initial velocity is in the negative x direction, then the phase constant ϕ is:

A) 0
B) $\pi/2$ radians
C) π radians
D) $3\pi/2$ radians
E) 2π radians

$X(0) = 0 = X_m \cos(\overset{0}{\omega t} + \phi)$

$V(0) = -X_m \omega \underset{\sin}{\cancel{\cos}}(\omega t + \phi)$

34. A lead block is suspended from your hand by a string. The reaction to the force of gravity on the block is the force exerted by the:

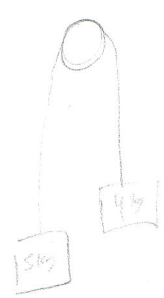
A) string on the block
B) block on the string
C) string on the hand
D) hand on the string
E) block on the Earth

35. An artificial Earth satellite is moved from a circular orbit with radius R to a circular orbit with radius $2R$. During this move:

A) the gravitational force does positive work, the kinetic energy of the satellite increases, and the potential energy of the Earth-satellite system increases
B) the gravitational force does positive work, the kinetic energy of the satellite increases, and the potential energy of the Earth-satellite system decreases
C) the gravitational force does positive work, the kinetic energy of the satellite decreases, and the potential energy of the Earth-satellite system increases
D) the gravitational force does negative work, the kinetic energy of the satellite system increases, and the potential energy of the Earth-satellite system decreases
E) the gravitational force does negative work, the kinetic energy of the satellite decreases, and the potential energy of the Earth-satellite system increases

36. A massless rope passes over a massless pulley suspended from the ceiling. A 4-kg block is attached to one end and a 5-kg block is attached to the other end. The acceleration of the 5-kg block is:

A) $g/4$
B) $5g/9$
C) $4g/9$
D) $g/5$
E) $g/9$



$a = F/M$

$\frac{9}{9} = \frac{5 \cdot 9.81}{5} + F_T \qquad -\frac{9}{9} = F_T - 9.81$

26. Three physical pendulums, with masses m_1, $m_2 = 2m_1$, and $m_3 = 3m_1$, have the same shape and size and are suspended at the same point. Rank them according to their periods, from shortest to longest.

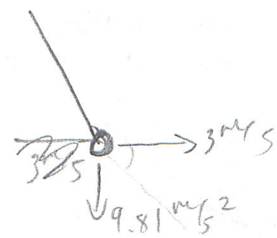
A) 1, 2, 3
B) 3, 2, 1
C) 2, 3, 1
D) 2, 1, 3
E) All the above are the same

$\omega = \sqrt{\frac{g}{m}} = 2\pi f$

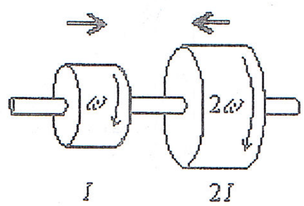
$T = 2\pi \sqrt{\frac{m}{g}}$

27. A car moves horizontally with a constant acceleration of 3 m/s^2. A ball is suspended by a string from the ceiling of the car; the ball does not swing, being at rest with respect to the car. What angle does the string make with the vertical?

A) 17°
B) 35°
C) 52°
D) 73°
E) Cannot be found without knowing the length of the string



28. Two disks are mounted on low-friction bearings on a common shaft. The first disc has rotational inertia I and is spinning with angular velocity ω. The second disc has rotational inertia $2I$ and is spinning in the same direction as the first disc with angular velocity 2ω as shown. The two disks are slowly forced toward each other along the shaft until they couple and have a final common angular velocity of:



A) $5\omega/3$
B) $\omega\sqrt{3}$
C) $\omega\sqrt{7/3}$
D) ω
E) 3ω

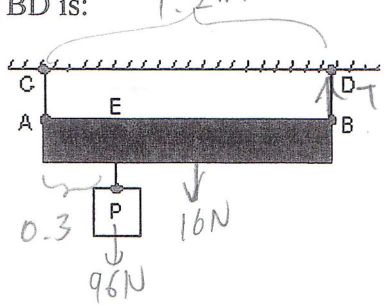
$L = I\omega$

$I\omega + 4I\omega$

$= 5I\omega / 3I$

$\omega = \frac{5}{3}\omega$

20. A uniform rod AB is 1.2 m long and weighs 16 N. It is suspended by strings AC and BD as shown. A block P weighing 96 N is attached at E, 0.30 m from A. The magnitude of the tension force in the string BD is:



A) 8.0 N
B) 24 N
C) 32 N
D) 48 N
E) 80 N

$\sum \tau = -96 \cdot 0.3 - 16 \cdot 0.6 + F_T \cdot 1.2$

$F_T = 32$

21. A pulley with radius R and rotational inertia I is free to rotate on a horizontal fixed axis through its center. A string passes over the pulley. A block of mass m_1 is attached to one end and a block of mass m_2, is attached to the other. At one time the block with mass m_1 is moving downward with speed v. If the string does not slip on the pulley, the magnitude of the total angular momentum, about the pulley center, of the blocks and pulley, considered as a system, is given by:

A) $(m_1 - m_2)vR + Iv/R$
B) $(m_1 + m_2)vR + Iv/R$
C) $(m_1 - m_2)vR - Iv/R$
D) $(m_1 + m_2)vR - Iv/R$
E) none of the above

$v = v$ m_2 m_1

22. A girl jogs around a horizontally circle with a constant speed. She travels one fourth of a revolution, a distance of 25 m along the circumference of the circle, in 5.0 s. The magnitude of her acceleration is: $v = v$

A) 0.31 m/s²
B) 1.3 m/s²
C) 1.6 m/s²
D) 3.9 m/s²
E) 6.3 m/s²

$25m \times \frac{1}{4} = 2\pi r$

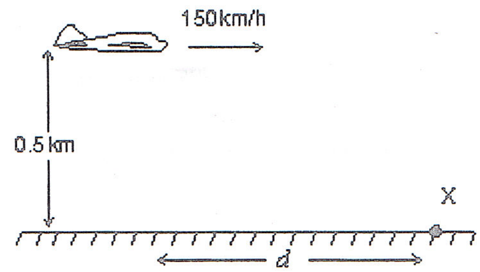
$R = 50/\pi$

25 m in 5 sec

$v = 5\ m/s$

$a = \frac{v^2}{R}$

12. The airplane shown is in level flight at an altitude of 0.50 km and a speed of 150 km/h. At what distance d should it release a heavy bomb to hit the target X? Take $g = 10$ m/s^2.



$150 \frac{km}{h} = 41.666 \, m/s$

$\times 10$

$= 416.6$

A) 150 m
B) 295 m
C) 417 m
D) 2550 m
E) 15,000 m

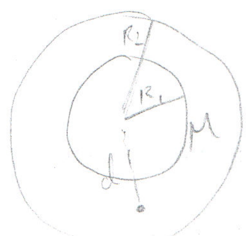
$500 = \frac{1}{2} a t^2$

$\sqrt{100} = t$

$t = 10$

13. A spherical shell has inner radius R_1, outer radius R_2, and mass M, distributed uniformly throughout the shell. The magnitude of the gravitational force exerted on the shell by a point mass particle of m a distance d from the center, outside the inner radius, is:

A) 0
B) GMm / R_1^2
C) GMm/d^2
D) $GMm / \left(R_2^2 - d^2\right)$
E) $GMm/(R_1 - d)^2$



$F = mg$

$mg = \frac{mG}{R^2}$

14. The escape velocity at the surface of Earth is approximately 8 km/s. What is the mass, in units of Earth's mass, of a planet with twice the radius of Earth for which the escape speed is twice that for Earth?

A) 2
B) 4
C) 8
D) 1/2
E) 1/4

M_{enc}

$V = \sqrt{\frac{2GM}{R}}$

$V^2 = \frac{2GM}{R}$

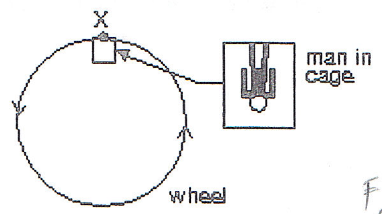
$R \to 2R$

$\frac{V^2 R}{2G} = M$

$V \to 2V$

$M = 8M$

5. A giant wheel, 40 m in diameter, is fitted with a cage and platform on which a man can stand. The wheel rotates at such a speed that when the cage is at X (as shown) the force exerted by the man on the platform is equal to his weight. The speed of the man is:



$F_c = 2mg = \frac{mv^2}{r}$

$\sqrt{2gr} = v$

$= 28$ m/s

A) 14 m/s
B) 20 m/s
C) 28 m/s
D) 80 m/s
E) 120 m/s

6. An object of mass m and another object of mass $2m$ are each forced to move along a circle of radius 1.0 m at a constant speed of 1.0 m/s. The magnitudes of their accelerations are:

A) equal
B) in the ratio of $\sqrt{2}$: 1
C) in the ratio of 2 : 1
D) in the ratio of 4 : 1
E) zero

$a_c = \frac{v^2}{r}$ no mass here

7. At time $t = 0$ a 2-kg particle has a velocity in m/s of $(4\text{ m/s})\hat{i} - (3\text{ m/s})\hat{j}$. At $t = 3$ s its velocity is $(2\text{ m/s})\hat{i} + (3\text{ m/s})\hat{j}$. During this time the work done on it was:

A) 4 J
B) −4 J
C) −12 J
D) −40 J
E) $(4\text{ J})\hat{i} + (36\text{ J})\hat{j}$

$W = \Delta KE = \sqrt{2^2+3^2} - \sqrt{4^2+3^2}$

$\cancel{\sqrt{13} - 5}$ $13 - 25$

8. A man pushes an 80-N crate a distance of 5.0 m upward along a frictionless slope that makes an angle of 30° with the horizontal. The force he exerts is parallel to the slope. If the speed of the crate is constant, then the work done by the man is:

A) −200 J
B) 61 J
C) 140 J
D) 200 J
E) 260 J

$W = F \cdot d$

$80 \cdot 5 \sin 30$