AP Physics B Forces & Circular Motion Test M **Name**______________________________ **Per**___

__D__ 1) A person weighing 490 newtons is standing on a bathroom scale in an elevator that is accelerating upward at a rate of 0.2 meter per second squared. What does the bathroom scale indicate the person's weight is?

(A) 480 N
(B) 490 N
(C) 588 N
(D) 500 N
(E) 392 N

$N - mg = ma$

__C__ 2) A hockey puck with a mass of 0.2 kilogram is sliding along ice that can be considered frictionless with a velocity of 10 meters per second. The puck then crosses over onto a rough floor that has a coefficient of kinetic friction equal to 0.2. How far will the puck travel before friction stops it?

(A) 17.6 m
(B) 42.7 m
(C) 25.5 m
(D) 59.6 m
(E) 62.3 m

$\Sigma F = ma$
$\mu mg = ma$
$a = 2\,m/s$
$v^2 = v_0^2 + 2a\Delta x$
$0 = 10^2 + 2(2)(\Delta x)$
$\Delta x = 25\,m$

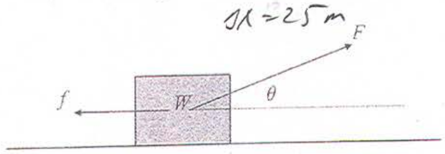


figure 16

__D__ 3) A weight W is pulled by a rope at an angle θ across a horizontal surface where the coefficient of kinetic friction is μ. Which of the following is true for the friction force f acting on the mass?

(A) $f = \mu W$
(B) $f = \mu(W + F\cos\theta)$
(C) $f = \mu(W + F\sin\theta)$
(D) $f = \mu(W - F\sin\theta)$
(E) $f \leq \mu(W - F\cos\theta)$

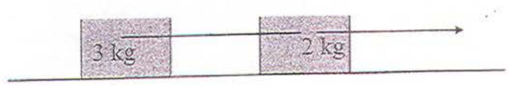


figure 17

__D__ 4) A tension T exists in the rope connecting the two masses. The value of F is

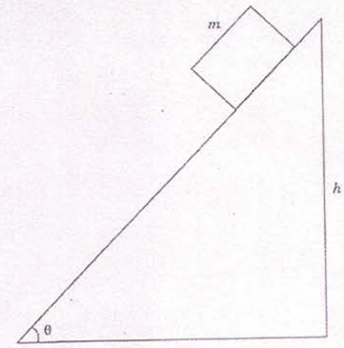
(A) $\frac{3}{2}T$ (B) $\frac{3}{5}T$ (C) T (D) $\frac{5}{3}T$ (E) $\frac{5}{2}T$

__D__ 5) A 15-kilogram ball is suspended by a rope from the ceiling. The magnitude of the force exerted on the ball by the rope is most nearly

(A) zero
(B) 1.5 N
(C) 15 N
(D) 150 N
(E) 200 N

$T = mg$

Questions 6-7) refer to the diagram of a block of mass m on a plane inclined at angle θ. The block is at height h from the ground.

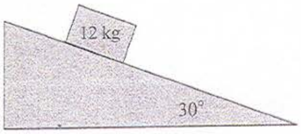


__C__ 6) If the block is released from rest, and there is no friction between the block and the inclined plane, what is the velocity of the block when it reaches the ground?

(A) $\sqrt{2mgh}$
(B) $\sqrt{mgh}$
(C) $\sqrt{2gh}$
(D) $\sqrt{gh}$
(E) $2gh^2$

__D__ 7) If the force of friction between the block and the incline is given by the equation $\mathbf{F}_{fr} = \mu\mathbf{N}$, where μ is the coefficient of kinetic friction, and $\mathbf{N}$ is the normal force, what is the acceleration of the block as it slides down the incline?

(A) $g\sin\theta$
(B) $\mu g\cos\theta$
(C) $\sin\theta(1 - \mu)$
(D) $g(\sin\theta - \mu\cos\theta)$
(E) $g(\sin\theta - \mu)$



D **8)**

figure 20

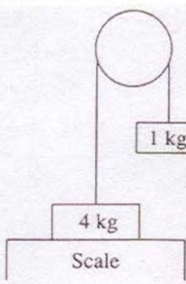
A 12-kg mass is at rest on a 30° incline where the coefficient of static friction is 0.8. The friction force exerted on the mass is most nearly

(A) 120 N
(B) 104 N
(C) 83 N
(D) 60 N
(E) 96 N

B **9)** A car slides up a frictionless inclined plane. How does the normal force of the incline on the car compare with the weight of the car?

(A) The normal force must be equal to the car's weight.
(B) The normal force must be less than the car's weight.
(C) The normal force must be greater than the car's weight.
(D) The normal force must be zero.
(E) The normal force could have any value relative to the car's weight.

C **10)**



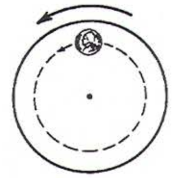
The figure above shows a pulley system in equilibrium. What is the weight read by the scale? Assume that $g = 10\ m/s^2$.

(A) 0 N
(B) 10 N
(C) 30 N
(D) 40 N
(E) 50 N

11) Three forces act on an object. If the object is in translational equilibrium, which of the following must be true?

I. The vector sum of the three forces must equal zero.
II. The magnitudes of the three forces must be equal
III. All three forces must be parallel

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



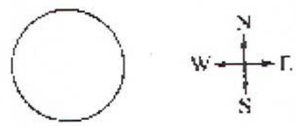
View from Above

D 12) The horizontal turntable shown above rotates at a constant rate. As viewed from above, a coin on the turntable moves counterclockwise in a circle as shown. Which of the following vectors best represents the direction of the frictional force exerted on the coin by the turntable when the coin is in the position shown?

(A) ←
(B) →
(C) ↙
(D) ↓
(E) ↑

B 13) When a person stands on a rotating merry-go-round, the frictional force exerted on the person by the merry-go-round is

(A) greater in magnitude than the frictional force exerted on the person by the merry-go-round
(B) opposite in direction to the frictional force exerted on the merry-go-round by the person
(C) directed away from the center of the merry-go-round
(D) zero if the rate of rotation is constant
(E) independent of the person's mass



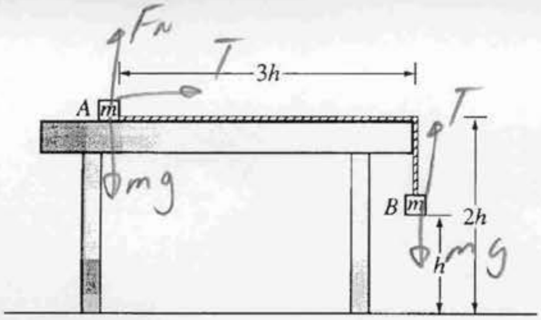
View of Track from Above

A 14) A racing car is moving around the circular track of radius 300 meters shown above. At the instant when the car's velocity is directed due east, its acceleration is directed due south and has a magnitude of 3 meters per second squared. When viewed from above, the car is moving

(A) clockwise at 30 m/s
(B) clockwise at 10 m/s
(C) counterclockwise at 30 m/s
(D) counterclockwise at 10 m/s
(E) with constant velocity

B 15) According to Coulomb's law, if the electric force between two charges is positive, which of the following must be true?

(A) One charge is positive and the other charge is negative.
(B) The force between the charges is repulsive.
(C) The force between the charges is attractive
(D) The two charges must be equal in magnitude.
(E) The force must be directed toward the larger charge.



1998B1 (15 points) Two small blocks, each of mass m, are connected by a string of constant length 4h and negligible mass. Block A is placed on a smooth tabletop as shown above, and block B hangs over the edge of the table. The tabletop is a distance 2h above the floor. Block A is then released from rest at a distance h above the floor at time t = 0. Express all algebraic answers in terms of h, m, and g.

(3) a. Determine the acceleration of block A as it descends.

$\Sigma F = ma$

$mg = 2ma$

$a = g/2$

(3) b. Block B strikes the floor and does not bounce. Determine the time $t = t_1$ at which block B strikes the floor.

$y_0 = 0$, $y = h$, $v_{y_0} = 0$, $a = g/2$

$y = y_0 + v_{y_0}t + \frac{1}{2}at^2$

$h = \frac{1}{2}\left(\frac{g}{2}\right)t^2$

$t = \sqrt{\frac{4h}{g}} = 2\sqrt{h/g}$

(2) c. Describe the motion of block A from time t = 0 to the time when block B strikes the floor.

Block A accelerates to the right at g/2.

(2) d. Describe the motion of block A from the time block B strikes the floor to the time block A leaves the table.

Block A continues to move to the right at a constant velocity.

(5) e. Determine the distance between the landing points of the two blocks.

Block A time to fall $= t = \sqrt{\frac{2(2h)}{g}} = 2\sqrt{h/g}$

$V_A = V_0 + at = \left(\frac{g}{2}\right)2\sqrt{h/g} = \sqrt{hg}$

$X_A = V_A t = (\sqrt{hg})(2\sqrt{h/g}) = 2h$

1995B3. (15 points) Part of the track of an amusement park roller coaster is shaped as shown above. A safety bar is oriented lengthwise along the top of each car. In one roller coaster car, a small 0.10-kilogram ball is suspended from this bar by a short length of light, inextensible string.

Note: Figure not drawn to scale.

(3) a. Initially, the car is at rest at point A.

i. On the diagram below, draw and label all the forces acting on the 0.10-kilogram ball.

ii. Calculate the tension in the string.

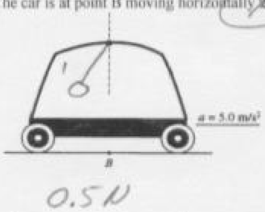
$\Sigma F = ma^{0}$ '

$T = mg = \boxed{0.98N}$

The car is then accelerated horizontally, goes up a 30° incline, goes down a 30° incline, and then goes around a vertical circular loop of radius 25 meters. For each of the four situations described in parts (b) to (e), do all three of the following. In each situation, assume that the ball has stopped swinging back and forth.

- Determine the horizontal component T_h of the tension in the string in newtons and record your answer in the space provided.
- Determine the vertical component T_v of the tension in the string in newtons and record your answer in the space provided.
- Show on the adjacent diagram the approximate direction of the string with respect to the vertical. The dashed line shows the vertical in each situation.

(3) b. The car is at point B moving horizontally to the right with an acceleration of 5.0 m/s. (typo)



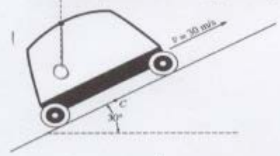
$T_h = ma = (0.1)5 = 0.5N$

$T_v = mg = 0.98N$

' T_h = 0.5N

' T_v = 0.98N

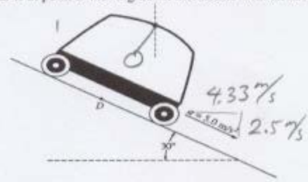
c. The car is at point C and is being pulled up the 30° incline with a constant speed of 30 m/s.



' T_h = 0

' T_v = 0.98N

d. The car is at point D moving down the incline with an acceleration of 5.0 m/s².



' T_h = 0.433N

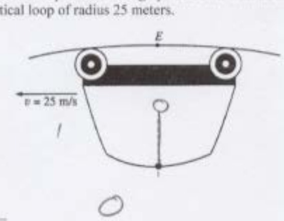
' T_v = 0.73 N

$T_h = m(4.33 \, m/s)$

$T_v - mg = ma$

$T_v = m(-2.5 + 9.8)$

e. The car is at point E moving upside down with an instantaneous speed of 25 m/s and no tangential acceleration at the top of the vertical loop of radius 25 meters.



$\Sigma F_v = m\frac{v^2}{r}$

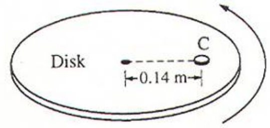
$T_v + mg = m\frac{v^2}{r}$

$T_v = m\left(\frac{v^2}{r} - g\right)$

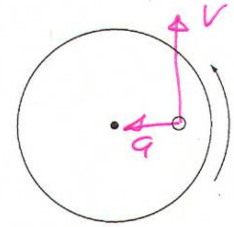
$= 0.1\left(\frac{25^2}{25} - 9.8\right)$

' T_h = 0

' T_v = 1.5N



99B5 (12 pts) A coin C of mass 0.0050 kg is placed on a horizontal disk at a distance of 0.14 m from the center, as shown above. The disk rotates at a constant rate in a counterclockwise direction as seen from above. The coin does not slip, and the time it takes for the coin to make a complete revolution is 1.5 s.



(2) a. The figure at the right shows the disk and coin as viewed from above. Draw and label vectors on the figure below to show the instantaneous acceleration and linear velocity vectors for the coin when it is at the position shown.

(2) b. Determine the linear speed of the coin.

$V = \frac{2\pi r}{T} = \frac{2\pi(0.14\,m)}{1.5\,s} = \boxed{0.59\,m/s}$

c. The rate of rotation of the disk is gradually increased. The coefficient of static friction between the coin and the disk is 0.50. Determine the linear speed of the coin when it just begins to slip.
(4)

$\Sigma F_c = m a_c$

$F_s = m\frac{v^2}{r}$

$\mu F_N = m\frac{v^2}{r}$

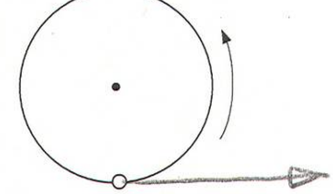
$\mu m g = m\frac{v^2}{r}$

$\boxed{V = 0.83\,m/s}$

(2) d. If the experiment in part (c) were repeated with a second, identical coin glued to the top of the first coin, how would this affect the answer to part (c)? Explain your reasoning.

No change!

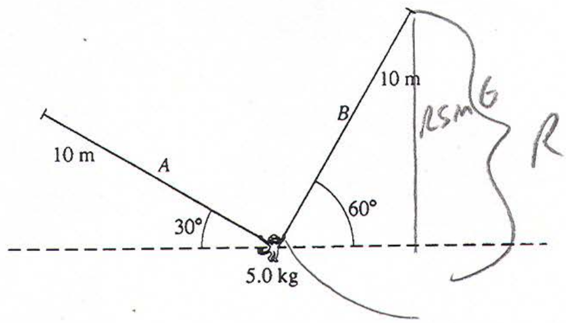
mass cancels out
or recalculation to show no effect



(2) e. The coin in experiment (c) slips on the rotating disk and arrives at the location shown in the picture at the right. From this starting position the coin slips off the rotating disk. Sketch the path the coin takes after it leaves the rotating platform as viewed form above.

1 pt – straight path

1 pt – ~~[illegible]~~ Departure from disk tangent to path



sin 30° = 0.50	sin 60° = 0.87
cos 30° = 0.87	cos 60° = 0.50
tan 30° = 0.58	tan 60° = 1.73

911. (8 points)
A 5.0-kilogram monkey hangs initially at rest from two vines, A and B. as shown above. Each of the vines has length 10 meters and negligible mass.

The monkey releases vine A and swings on vine B. Neglect air resistance.

(4) c. Determine the speed of the monkey as it passes through the lowest point of its first swing.

1 $E_1 = E_2$

1 $mgh = \frac{1}{2}mv^2$ → $9.8(1.34\,m) = \frac{1}{2}v^2$

1 $h = R - R\sin\theta$
$= 10m - 10\sin 60$
$= 1.34m$

1 $v = 5.1\,m/s$

d. Determine the tension in vine B as the monkey passes through the lowest point of its first swing.

(4)

1 $\Sigma F_c = ma_c$

1 $T - mg = m\frac{v^2}{r}$ 1

$T - 5(9.8) = \frac{5(5.1)^2}{10m}$

1 $T = 62.1N$