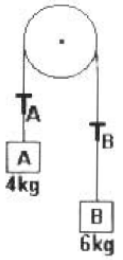
National High School Physics Contest (NHSPC) Sample Problems

1. A simple Atwood's machine is shown in the diagram below. It is composed of a frictionless lightweight pulley with two cubes connected by a light string. If cube A has a mass of 4.0 kg and cube B has a mass of 6.0 kg, the system will move such that cube B accelerates downwards. The gravitational acceleration g is given by g=9.8m/s^2 What would be the tension in the two parts of the string between the pulley and the cubes?

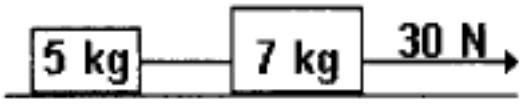


(A) TA = 47 N ; TB = 71 N
(B) TA = 47 N ; TB = 47 N
(C) TA = 47 N ; TB = 42 N
(D) TA = 39 N ; TB = 59 N
(E) TA = 39 N ; TB = 39 N
(F) TA = 71 N ; TB = 71 N
(G) TA = 42 N ; TB = 42 N
(H) TA = 59 N ; TB = 59 N
(I) TA = 71 N ; TB = 47 N
(J) TA = 59 N ; TB = 42 N

2. A solid cylinder of mass m, radius r, and rotational inertia $\frac{1}{2}mr^2$, starts at rest from the top of a ramp of height h. If the cylinder rolls without slipping down the ramp which makes an incline of 30° with the horizontal, what would be the speed of the cylinder at the bottom?

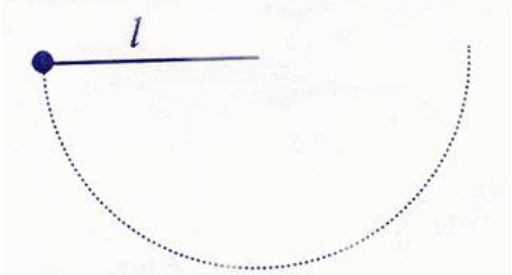
(A) $2\sqrt{gh}$
(B) $2\sqrt{\frac{gh}{6}}$
(C) $\frac{4}{3}\sqrt{\frac{gh}{2}}$
(D) gh
(E) $2gh$
(F) $\frac{4gh}{3}$
(G) $\sqrt{2gh}$
(H) $\frac{4}{3}\sqrt{gh}$
(I) $\sqrt{gh}$
(J) $2\sqrt{\frac{gh}{3}}$

3. Two masses 5.0 and 7.0 kg are originally at rest on a frictionless surface. The masses are connected by a light cord. A second cord is attached to the 7.0 kg mass and pulled with a horizontal force of 30 N. What is the tension in the cord that connects the two masses?



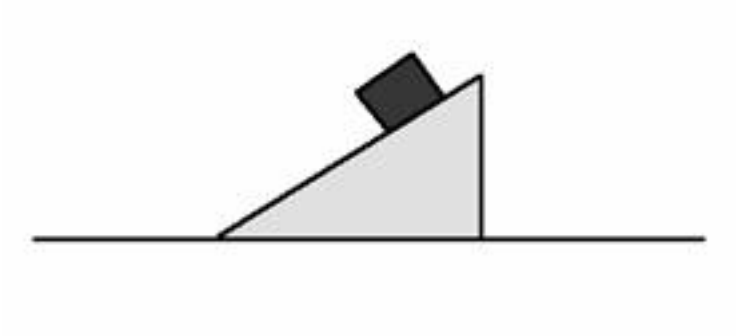
(A) 2.5 N
(B) 5 N
(C) 6 N
(D) 7 N
(E) 10 N
(F) 12.5 N
(G) 15 N
(H) 17.5 N
(I) 23.5 N
(J) 30 N

4. A ball of mass *m* is attached to a light string of length *l*. The ball is held with the string horizontal as shown in the diagram below. Then, the ball is released. What is the tension in the string when the ball is at its lowest point?



(A) zero
(B) *mg*
(C) 2*mg*
(D) 3*mg*
(E) 4*mg*
(F) 5mg
(G) 6mg
(H) 7mg
(I) 8mg
(J) none of above

5. A large wedge rests on a horizontal frictionless surface, as shown. A block starts from rest and slides down the inclined surface of the wedge, which is rough. During the motion of the block, which of the following statements is true regarding the center of mass of the block and wedge?

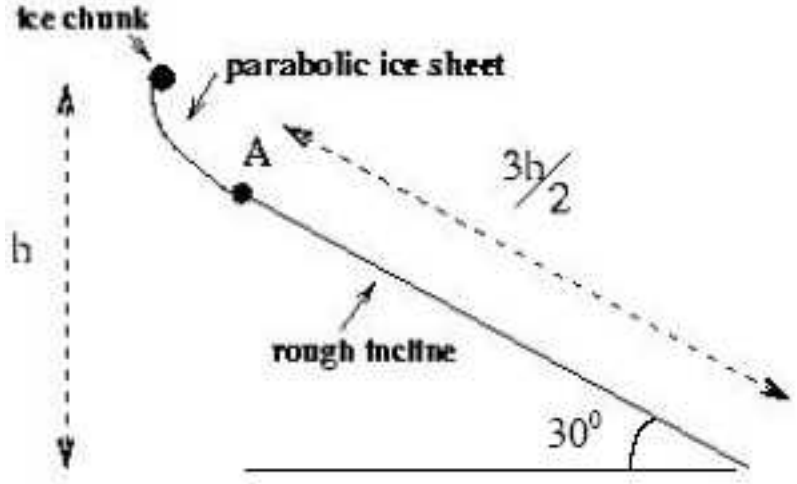


(A) the center of mass does not move
(B) the center of mass moves only horizontally with constant speed
(C) the center of mass moves only horizontally with increasing speed
(D) the center of mass moves only vertically with constant speed
(E) the center of mass moves only vertically with increasing speed
(F) the center of mass moves both horizontally and vertically with constant speed
(G) the center of mass moves both horizontally and vertically with increasing speed
(H) the center of mass moves horizontally with constant speed but vertically with increasing speed
(I) the center of mass moves horizontally with increasing speed but vertically with constant speed
(J) none of above

6. A baseball is dropped on top of a basketball. The basketball hits the ground, rebounds with a speed of 4.0 m/s, and collides with the baseball as it is moving downward at 4.0 m/s. After the collision, the baseball moves upward as shown in the figure and the basketball is instantaneously at rest right after the collision. The mass of the baseball is 0.2 kg and the mass of the basketball is 0.5 kg. Ignore air resistance and ignore any changes in velocities due to gravity during the very short collision times. What is the speed of the baseball right after colliding with the upward moving basketball?

(A) zero
(B) 20.0 m/s
(C) 16.0 m/s
(D) 12.0 m/s
(E) 10.0 m/s
(F) 8.0 m/s
(G) 6.0 m/s
(H) 4.0 m/s
(I) 2.0 m/s
(J) none of above

7. A small chunk of ice falls from rest down a frictionless parabolic ice sheet as shown in the figure. At the point labeled **A** in the diagram, the ice sheet becomes a steady, rough incline of angle 30°; with respect to the horizontal and friction coefficient μ_k. This incline is of length (3/2)*h* and ends at a cliff. The chunk of ice comes to rest precisely at the end of the incline. What is the coefficient of friction μ_k?



(A) 0.333
(B) 0.385
(C) 0.577
(D) 0.667
(E) 0.770
(F) 0.866
(G) 1.000
(H) 1.300
(I) 1.500
(J) not enough information to determine

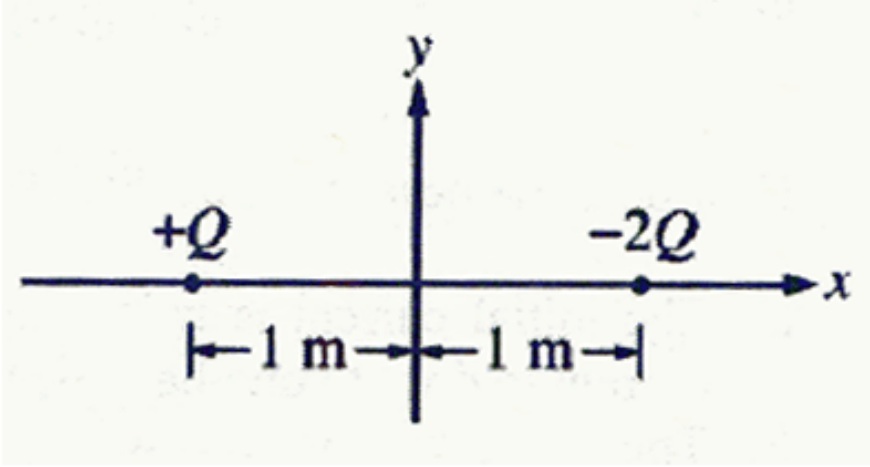
8. An experiment consists of pulling a heavy wooden block across a level surface with a spring force meter. The constant force for each try is recorded, as is the acceleration of the block. The data are shown below.

Force F in Newtons	3.05	3.45	4.05	4.45	5.05
Acceleration a in meter/seconds^2	0.095	0.205	0.295	0.405	0.495

Which is the best value for the mass of the block?

(A) 70 kg
(B) 60 kg
(C) 50 kg
(D) 40 kg
(E) 30 kg
(F) 20 kg
(G) 10 kg
(H) 5 kg
(I) 3 kg
(J) 1 kg

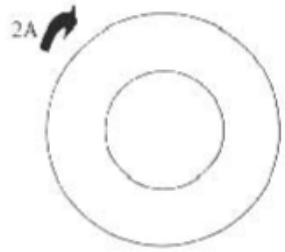
9. A charge of +*Q* is located on the *x*-axis at *x* = -1 meter and a charge of -2*Q* is held at *x* = +1 meter, as shown in the diagram below. At what position on the *x*-axis will a test charge of +*q* experience a zero net electrostatic force?



(A) $-\left(3+\sqrt{8}\right)m$
(B) $-2m$
(C) $-1m$
(D) $-\frac{1}{3}m$
(E) $0m$

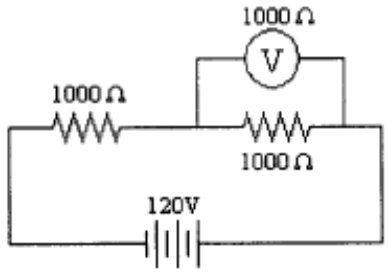
(F) $\frac{1}{3}m$
(G) $1m$
(H) $2m$
(I) $\left(3+\sqrt{8}\right)m$
(J) Cannot determine since the magnitude of the charges are not given

10. Two unconnected circular loops of wire lie in the same plane with the same center as shown in the diagram below. The outer loop carries current of 2 A in a clockwise direction and has twice the radius of the inner loop. If the magnetic field at the center of the loops is zero, then what must the current in the inner loop be?



(A) Cannot determine since the radii are not given
(B) 0 A
(C) 3A in the counterclockwise direction
(D) 3A in the clockwise direction
(E) 2 A in the counterclockwise direction
(F) 2 A in the clockwise direction
(G) 1.5 A in the counterclockwise direction
(H) 1.5 A in the clockwise direction
(I) 1 A in the counterclockwise direction
(J) 1 A in the clockwise direction

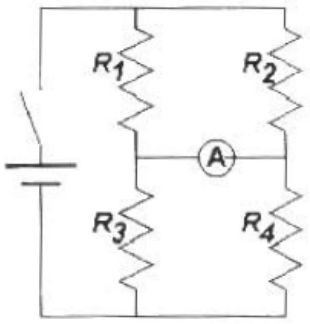
11. Two 1000 Ω resistors are connected in series to a 120-volt electrical source. A voltmeter with a resistance of 1000 Ω is connected across the last resistor as shown. What would be the reading on the voltmeter?



(A) 0 V
(B) 5 V
(C) 10 V

(D) 15 V
(E) 20 V
(F) 30 V
(G) 40 V
(H) 60 V
(I) 80 V
(J) 120 V

12. Four resistors, R_1, R_2, R_3, and R_4, are connected as shown in the circuit diagram below. When the switch is closed, current flows in the circuit. If no current flows through the ammeter when it is connected as shown, what would be the value of R_3?



(A) $\frac{R_1 + R_4}{(R_1 + R_2)(R_3 + R_4)}$

(B) $\frac{(R_1 + R_2)R_4}{(R_2 + R_4)}$

(C) $\frac{R_1 + R_2}{R_4}$

(D) $R_2 + R_4 - R_1$

(E) R_1

(F) R_4

(G) R_2

(H) $\frac{(R_1 + R_4)R_2}{(R_1 + R_2)}$

(I) $\frac{(R_2 + R_4)R_1}{(R_1 + R_2)}$

(J) $R_1 \frac{R_4}{R_2}$