Name: KEY

Directions (1–35): For *each* statement or question, write on the separate answer sheet the *number* of the word or expression that, of those given, best completes the statement or answers the question.

1 Which is a vector quantity?

(1) speed
(2) work
(3) mass
(4) displacement

2 A race car starting from rest accelerates uniformly at a rate of 4.90 meters per second^2. What is the car's speed after it has traveled 200. meters?

(1) 1960 m/s
(2) 62.6 m/s
(3) 44.3 m/s
(4) 31.3 m/s

3 A ball is thrown straight downward with a speed of 0.50 meter per second from a height of 4.0 meters. What is the speed of the ball 0.70 second after it is released? [Neglect friction.]

(1) 0.50 m/s
(2) 7.4 m/s
(3) 9.8 m/s
(4) 15 m/s

4 A soccer player kicks a ball with an initial velocity of 10. meters per second at an angle of 30.° above the horizontal. The magnitude of the horizontal component of the ball's initial velocity is

(1) 5.0 m/s
(2) 8.7 m/s
(3) 9.8 m/s
(4) 10. m/s

5 Which object has the greatest inertia?

(1) a 5.00-kg mass moving at 10.0 m/s
(2) a 10.0-kg mass moving at 1.00 m/s
(3) a 15.0-kg mass moving at 10.0 m/s
(4) a 20.0-kg mass moving at 1.00 m/s

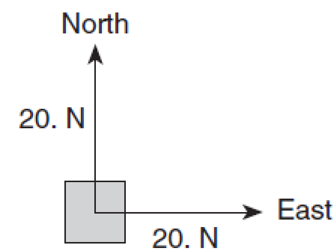
6 A 60.-kilogram physics student would weigh 1560 newtons on the surface of planet *X*. What is the magnitude of the acceleration due to gravity on the surface of planet *X*?

(1) 0.038 m/s^2
(2) 6.1 m/s^2
(3) 9.8 m/s^2
(4) 26 m/s^2

7 Two spheres, *A* and *B*, are simultaneously projected horizontally from the top of a tower. Sphere *A* has a horizontal speed of 40. meters per second and sphere *B* has a horizontal speed of 20. meters per second. Which statement best describes the time required for the spheres to reach the ground and the horizontal distance they travel? [Neglect friction and assume the ground is level.]

(1) Both spheres hit the ground at the same time and at the same distance from the base of the tower.
(2) Both spheres hit the ground at the same time, but sphere *A* lands twice as far as sphere *B* from the base of the tower.
(3) Both spheres hit the ground at the same time, but sphere *B* lands twice as far as sphere *A* from the base of the tower.
(4) Sphere *A* hits the ground before sphere *B*, and sphere *A* lands twice as far as sphere *B* from the base of the tower.

8 In the diagram below, a 20.-newton force due north and a 20.-newton force due east act concurrently on an object, as shown in the diagram below.



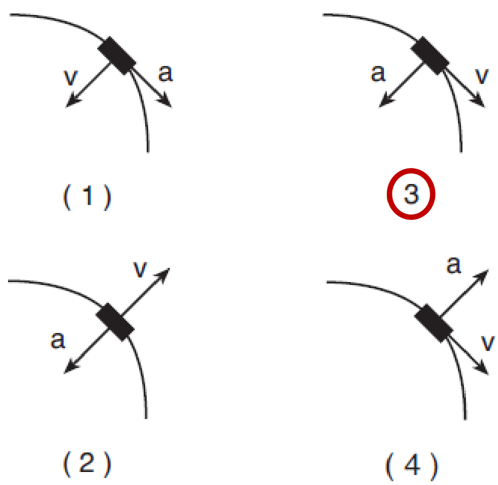
The additional force necessary to bring the object into a state of equilibrium is

(1) 20. N, northeast
(2) 20. N, southwest
(3) 28 N, northeast
(4) 28 N, southwest

9 A car's performance is tested on various horizontal road surfaces. The brakes are applied, causing the rubber tires of the car to slide along the road without rolling. The tires encounter the greatest force of friction to stop the car on

(1) dry concrete
(2) dry asphalt
(3) wet concrete
(4) wet asphalt

10 A car rounds a horizontal curve of constant radius at a constant speed. Which diagram best represents the directions of both the car's velocity, v, and acceleration, a?



11 A 6.0-kilogram block, sliding to the east across a horizontal, frictionless surface with a momentum of 30. kilogram•meters per second, strikes an obstacle. The obstacle exerts an impulse of 10. newton•seconds to the west on the block. The speed of the block after the collision is

(1) 1.7 m/s
(2) 3.3 m/s
(3) 5.0 m/s
(4) 20. m/s

12 If a 65-kilogram astronaut exerts a force with a magnitude of 50. newtons on a satellite that she is repairing, the magnitude of the force that the satellite exerts on her is

(1) 0 N
(2) 50. N less than her weight
(3) 50. N more than her weight
(4) 50. N

13 A 1.0-kilogram laboratory cart moving with a velocity of 0.50 meter per second due east collides with and sticks to a similar cart initially at rest. After the collision, the two carts move off together with a velocity of 0.25 meter per second due east. The total momentum of this frictionless system is

(1) zero before the collision
(2) zero after the collision
(3) the same before and after the collision
(4) greater before the collision than after the collision

14 Student *A* lifts a 50.-newton box from the floor to a height of 0.40 meter in 2.0 seconds. Student *B* lifts a 40.-newton box from the floor to a height of 0.50 meter in 1.0 second. Compared to student *A*, student *B* does

(1) the same work but develops more power
(2) the same work but develops less power
(3) more work but develops less power
(4) less work but develops more power

15 While riding a chairlift, a 55-kilogram skier is raised a vertical distance of 370 meters. What is the total change in the skier's gravitational potential energy?

(1) 5.4×10^1 J
(2) 5.4×10^2 J
(3) 2.0×10^4 J
(4) 2.0×10^5 J

16 The work done on a slingshot is 40.0 joules to pull back a 0.10-kilogram stone. If the slingshot projects the stone straight up in the air, what is the maximum height to which the stone will rise? [Neglect friction.]

(1) 0.41 m
(2) 41 m
(3) 410 m
(4) 4.1 m

Directions (36–49): For *each* statement or question, write on the separate answer sheet the *number* of the word or expression that, of those given, best completes the statement or answers the question.

36 A joule is equivalent to a

(1) N•m (3) N/m
(2) N•s (4) N/s

37 The weight of a chicken egg is most nearly equal to

(1) 10^{-3} N (3) 10^{0} N
(2) 10^{-2} N (4) 10^{2} N

38 Two forces act concurrently on an object. Their resultant force has the largest magnitude when the angle between the forces is

(1) 0° (3) 90°
(2) 30° (4) 180°

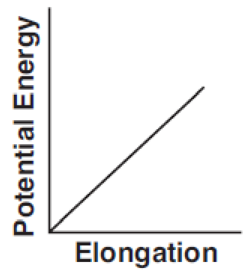
39 A bicycle and its rider have a combined mass of 80. kilograms and a speed of 6.0 meters per second. What is the magnitude of the average force needed to bring the bicycle and its rider to a stop in 4.0 seconds?

(1) 1.2×10^{2} N (3) 4.8×10^{2} N
(2) 3.2×10^{2} N (4) 1.9×10^{3} N

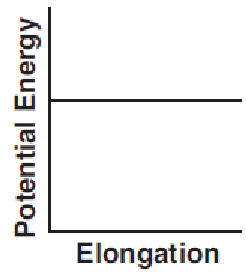
40 Gravitational forces differ from electrostatic forces in that gravitational forces are

(1) attractive, only
(2) repulsive, only
(3) neither attractive nor repulsive
(4) both attractive and repulsive

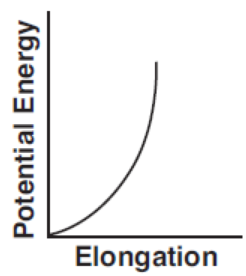
41 Which graph best represents the relationship between the elastic potential energy stored in a spring and its elongation from equilibrium?



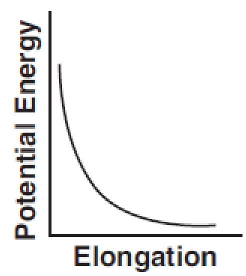
(1)



(3)



(2)



(4)

42 A car with mass m possesses momentum of magnitude p. Which expression correctly represents the kinetic energy, KE, of the car in terms of m and p?

(1) $KE = \frac{1}{2}\frac{p}{m}$ (3) $KE = \frac{1}{2}mp$
(2) $KE = \frac{1}{2}mp^2$ (4) $KE = \frac{1}{2}\frac{p^2}{m}$

50 A spring in a toy car is compressed a distance, *x*. When released, the spring returns to its original length, transferring its energy to the car. Consequently, the car having mass *m* moves with speed *v*.

Derive the spring constant, *k*, of the car's spring in terms of *m*, *x*, and *v*. [Assume an ideal mechanical system with no loss of energy.] [Show all work, including the equations used to derive the spring constant.] [2]

$PE_s = ½ k x^2 = KE = ½ m v^2$
$k x^2 = m v^2$
$k = m v^2 / x^2$

Base your answers to questions 51 and 52 on the information below.

A 75-kilogram athlete jogs 1.8 kilometers along a straight road in 1.2×10^3 seconds.

51 Determine the average speed of the athlete in meters per second. [1]

m = 75 kg
d = 1800 m
t = 1200 s
$\bar{v}$ = ?

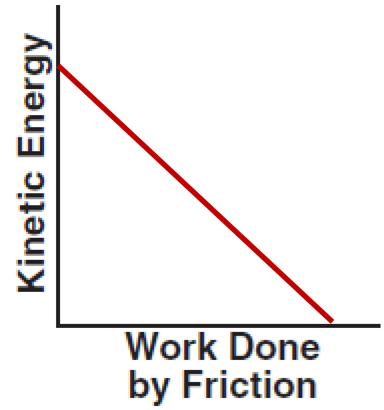
$\bar{v}$ = d / t
= 1800 m ÷ 1200 s
= 1.5 m/s

52 Calculate the average kinetic energy of the athlete. [Show all work, including the equation and substitution with units.] [2]

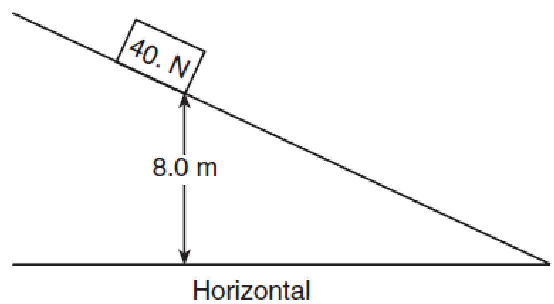
m = 75 kg
$\bar{v}$ = 1.5 m/s

$KE = ½ mv^2$
$= ½\ 75\ kg \times (1.5\ m/s)^2$
= 84.375 J
= 84 J

55 A car, initially traveling at 30. meters per second, slows uniformly as it skids to a stop after the brakes are applied. On the axes *in your answer booklet*, sketch a graph showing the relationship between the kinetic energy of the car as it is being brought to a stop and the work done by friction in stopping the car. [1]



18 A block weighing 40. newtons is released from rest on an incline 8.0 meters above the horizontal, as shown in the diagram below.



If 50. joules of heat is generated as the block slides down the incline, the maximum kinetic energy of the block at the bottom of the incline is

(1) 50. J
(2) 270 J
(3) 320 J
(4) 3100 J

Base your answers to questions 63 through 66 on the information and data table below.

A 1.00-kilogram mass was dropped from rest from a height of 25.0 meters above Earth's surface. The speed of the mass was determined at 5.0-meter intervals and recorded in the data table below.

Data Table

Height Above Earth's Surface (m)	Speed (m/s)
25.0	0.0
20.0	9.9
15.0	14.0
10.0	17.1
5.0	19.8
0	22.1

Directions (63-66): Using the information in the data table, construct a graph on the grid below the directions for 63-66.

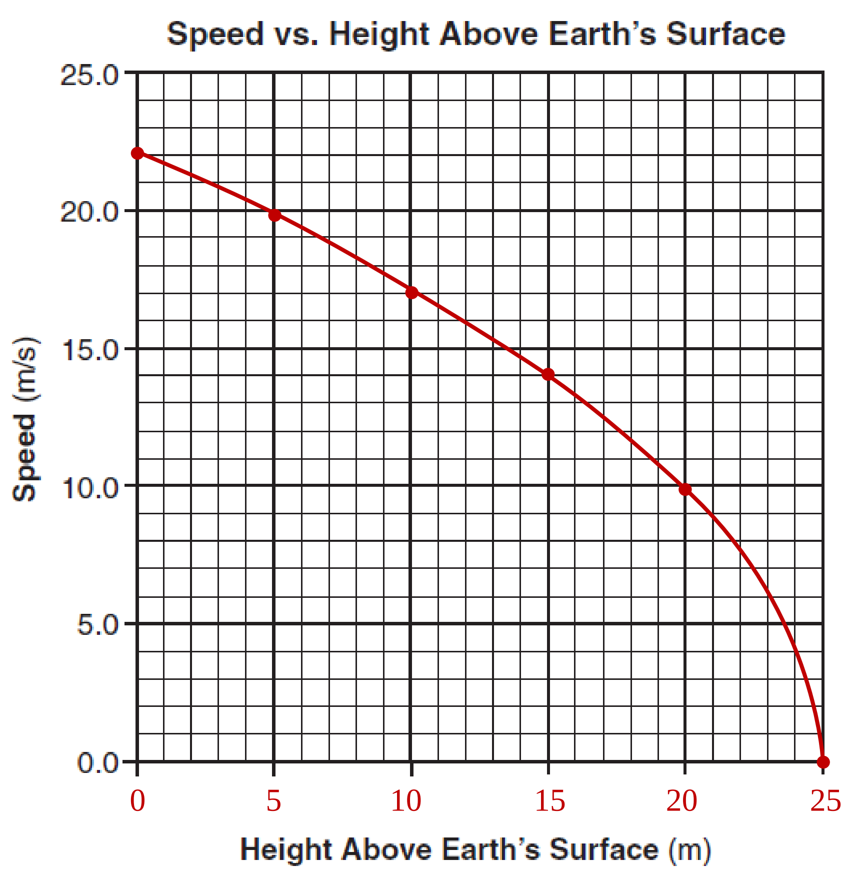
63 Mark an appropriate scale on the axis labeled "Height Above Earth's Surface (m)." [1]

64 Plot the data points for speed versus height above Earth's surface. [1]

65 Draw the line or curve of best fit. [1]

66 Using your graph, determine the speed of the mass after it has fallen a vertical distance of 12.5 meters. [1]

15.7 m/s



Base your answers to questions 71 and 72 on the information below.

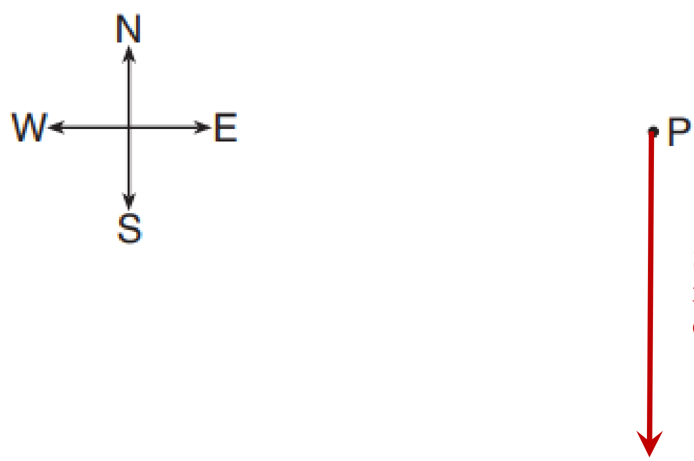
A 747 jet, traveling at a velocity of 70. meters per second north, touches down on a runway. The jet slows to rest at the rate of 2.0 meters per second^2.

71 Calculate the total distance the jet travels on the runway as it is brought to rest. [Show all work, including the equation and substitution with units.] [2]

v = 70. m/s
a = −2.0 m/s^2
d = ?

$v_f^2 = v_i^2 + 2ad$
$0 = (70.\ m/s)^2 + 2(-2.0\ m/s^2)d$
$d = -4900.\ m^2/s^2 \div -4.0\ m/s^2$
$= 1225$ m
$= 1200$ m

72 On the diagram *below*, point *P* represents the position of the jet on the runway. Beginning at point *P*, draw a vector to represent the magnitude and direction of the acceleration of the jet as it comes to rest.
Use a scale of 1.0 centimeter = 0.50 meter/second^2.



Should be 4.00 cm but it is hard to measure on a computer screen.

Base your answers to questions 73 and 74 on the information below.

Io (pronounced "EYE oh") is one of Jupiter's moons discovered by Galileo. Io is slightly larger than Earth's Moon.

The mass of Io is 8.93×10^{22} kilograms and the mass of Jupiter is 1.90×10^{27} kilograms. The distance between the centers of Io and Jupiter is 4.22×10^{8} meters.

73 Calculate the magnitude of the gravitational force of attraction that Jupiter exerts on Io. [Show all work, including the equation and substitution with units.] [2]

$m_{Io} = 8.93 \times 10^{22}$ kg
$m_J = 1.90 \times 10^{27}$ kg
$d = 4.22 \times 10^{8}$ m
$G = 6.67 \times 10^{-11}$ N•m²/kg²

$F_g = Gm_1m_2/d^2$
$= (6.67 \times 10^{-11}\ \text{N•m}^2/\text{kg}^2)(8.93 \times 10^{22}\ \text{kg})(1.90 \times 10^{27}\ \text{kg}) / (4.22 \times 10^{8}\ \text{m})^2$
$= 6.35 \times 10^{22}$ N

74 Calculate the magnitude of the acceleration of Io due to the gravitational force exerted by Jupiter. [Show all work, including the equation and substitution with units.] [2]

$a = ?$
$m = 8.93 \times 10^{22}$ kg
$F = 6.35 \times 10^{22}$ N

$F = ma$ $\quad \therefore a = F/m$
$a = 6.35 \times 10^{22}\ \text{N} / 8.93 \times 10^{22}\ \text{kg}$
$= 0.712\ \text{m/s}^2$