All questions are of equal value. No marks are subtracted for wrong answers.

Record all answers on the computer score sheet provided. USE PENCIL ONLY! Black pen will look good but may not be read reliably by the scoring machine. Mark only one answer for each question! Select the answer which is closest to yours.

A formula sheet is provided for your use; you may not use your own formula sheet. Calculators should have limited memory capacity and should not be capable of remote communication. No phones or handheld computers (PDAs) or notes are permitted.

Unless the question specifically asks about significant figures, an answer should NOT be considered to be incorrect if the number of significant figures does not match the significant figures supplied in the question.

Be sure your name and 7-digit student number are printed on the score sheet and your student number is correctly coded in the box at the top right-hand side of the sheet.

TABLE OF CONSTANTS

$G = 6.674 \times 10^{-11}\ m^3 kg^{-1} s^{-2}$	Standard atmospheric pressure = 1.013×10^5 Pa
$g = 9.80\ m/s^2$	Specific heat capacity of water = 4186 J/(kg C°)
Density of water = $1000\ kg/m^3$	Specific heat capacity of ice = 2000 J/(kg C°)
1 calorie = 4.186 J	Specific heat capacity of steam = 2010 J/(kg Cº)
Mass of the earth = 5.98×10^{24} kg	Latent heat of fusion of water, $L_f = 3.35 \times 10^5$ J/kg
Radius of the earth = 6.38×10^3 km	Latent heat of vaporization of water, $L_v = 2.26 \times 10^6$ J/kg

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1. A certain physical quantity, R, is calculated using the formula: $R = 4a(b - c)$ where a, b, and c are distances. What is the SI unit for R?

(a) cm (b) cm^2 (c) m (d) m^2 (e) m^3

2. A car traveling along a road at a speed of 7.0 m/s begins accelerating with a constant acceleration of 1.5 m/s^2 in the direction of motion. What is its speed after traveling 392 m with this acceleration?

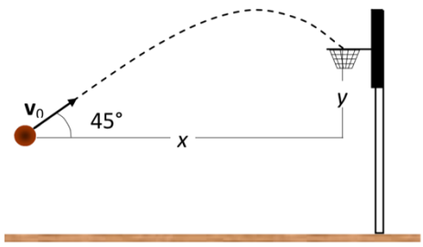
(a) 1.5 m/s (b) 7.0 m/s (c) 35 m/s (d) 49 m/s (e) 2.3 m/s

3. A brick is dropped from rest from a height of 9.8 m. How long does it take the brick to reach the ground?

(a) 0.6 s (b) 1.0 s (c) 1.2 s (d) 1.4 s (e) 2.0 s

4. A basketball is launched with an initial speed of 8.0 m/s and follows the trajectory shown. The ball enters the basket 0.96 s after it is launched. What are the distances x and y?
Note: *The drawing is not to scale.*

	x	y
(a)	5.4 m	0.73 m
(b)	7.7 m	0.91 m
(c)	5.4 m	0.91 m
(d)	5.7 m	0.73 m
(e)	5.4 m	5.4 m



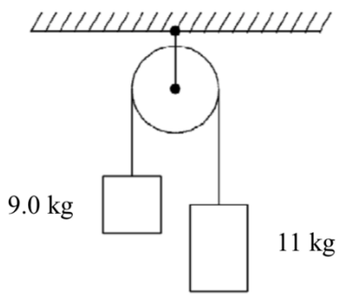
5. A boy pulls a sled of mass 5.0 kg with a rope that makes a 60.0° angle with respect to the horizontal surface of a frozen pond. The boy pulls on the rope with a force of 10.0 N and the sled moves with constant velocity. What is the coefficient of friction between the sled and the ice?

(a) 0.09 (b) 0.18 (c) 0.24 (d) 0.12 (e) 0.06

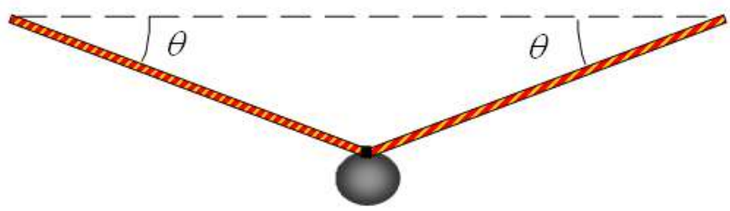
6. Two blocks with masses 9.0 kg and 11 kg are connected by a string and pulley as shown. Assuming that the string and pulley are massless, the magnitude of the acceleration is

(a) 0.98 m/s^2 (b) 8.0 m/s^2 (c) 2.0 m/s^2

(d) 9.8 m/s^2 (e) n.o.t.



7. A muscle builder holds the ends of a massless rope. At the center of the rope, a 7.9-kg ball is hung as shown. What is the tension in the rope if the angle θ in the drawing is 6.0°?



(a) 960 N
(b) 740 N
(c) 370 N
(d) 230 N
(e) 150 N

8. A certain string breaks when it is under 25 N of tension. A boy uses this string to whirl a 1.5-kg stone in a horizontal circle. The boy continuously increases the speed of the stone until the string breaks. If the radius of the circular motion at the breaking point is 2.0 m, what is the speed of the stone?

(a) 5.2 m/s (b) 6.1 m/s (c) 8.0 m/s (d) 13 m/s (e) 18 m/s

9. The orbital radius of Saturn about the Sun is about 10 times that of Earth. Complete the following statement:

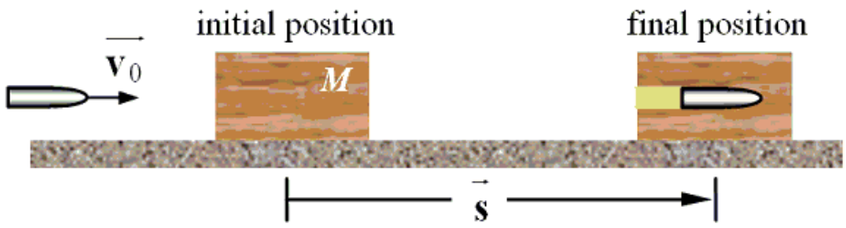
The period of Saturn is about

(a) 10 yr (b) 40 yr (c) 160 yr (d) 30 yr (e) 90 yr

10. A 102-kg man runs up a flight of stairs in 5.0 s. His net vertical displacement is 5.0 m. Approximately, what average power did the man exert while he was running?

(a) 5.0 kW (b) 1.0 kW (c) 0.75 kW (d) 0.50 kW (e) 0.25 kW

11. A bullet of mass m is fired at speed v_0 into a wooden block of mass M. The bullet instantaneously comes to rest in the block. The block with the embedded bullet slides along a horizontal surface with a coefficient of kinetic friction μ.



Which one of the following expressions determines how far the block slides before it comes to rest (the magnitude of displacement $\vec{s}$ in the figure)?

(a) $s = \dfrac{mv_0^2}{M\mu g}$ (b) $s = \dfrac{m}{m+M}\left(\dfrac{v_0^2}{\mu g}\right)$ (c) $s = \left(\dfrac{m}{m+M}\right)^2 \dfrac{v_0^2}{2\mu g}$

(d) $s = \left(\dfrac{m}{m+M}\right)^2 \sqrt{\dfrac{v_0^2}{2\mu g}}$ (e) $s = \dfrac{v_0^2}{\mu g}$

12. A 0.065-kg tennis ball moving to the right with a speed of 13 m/s is struck by a tennis racket, causing it to move to the left with a speed of 17 m/s. If the ball remains in contact with the racquet for 0.012 s, what is the magnitude of the average force exerted on the ball?

(a) zero newtons (b) 98 N (c) 160 N (d) 240 N (e) 320 N

13. Complete the following statement: Momentum will be conserved in a two-body collision *only if*

(a) both bodies come to rest.
(b) the collision is perfectly elastic.
(c) the kinetic energy of the system is conserved.
(d) the net external force acting on the two-body system is zero.
(e) the internal forces of the two-body system cancel in action-reaction pairs.

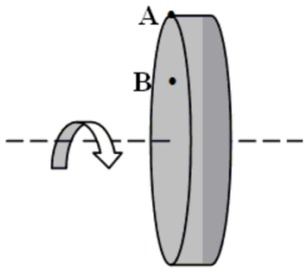
14. A 100-kg fisherman and a 500-kg supply crate are on a frozen pond that is essentially frictionless. The man and the crate are initially separated by a distance of 60 meters. The fisherman uses a very light rope to pull the crate closer to him. How far has the man moved when the crate reaches the fisherman?

(a) zero meters (b) 10 m (c) 30 m (d) 50 m (e) 60 m

15. A spinning disc rotating at 817 rad/min slows and stops 31 s later. How many revolutions did the disc make during this time?

(a) 34 (b) 67 (c) 8.4 (d) 17 (e) 4.2

16. Two points are located on a rigid wheel that is rotating with decreasing angular velocity about a fixed axis. Point A is located on the rim of the wheel and point B is halfway between the rim and the axis. Which one of the following statements concerning this situation is true?

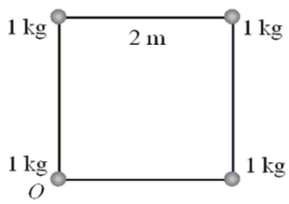


(a) Both points have the same centripetal acceleration.
(b) Both points have the same tangential velocity.
(c) The angular velocity at point A is greater than that of point B.
(d) Both points have the same instantaneous angular velocity.
(e) Each second, point A turns through a greater angle than point B.

17. A 60.0-kg skater begins a spin with an angular speed of 6.0 rad/s. By changing the position of her arms, the skater decreases her moment of inertia to one-third its initial value. What is the skater's final angular speed?

(a) 3.0 rad/s (b) 4.5 rad/s (c) 9.0 rad/s (d) 12 rad/s (e) 18 rad/s

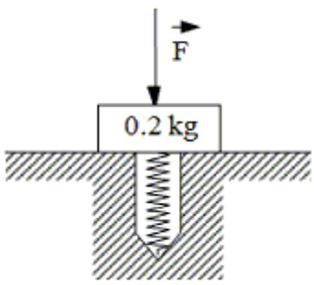
18. A *massless* frame in the shape of a square with 2-m sides has a 1-kg ball at each corner. What is the moment of inertia of the four balls about an axis through the corner marked *O* and perpendicular to the plane of the paper?



(a) 4 kg·m^2 (b) 8 kg·m^2 (c) 10 kg·m^2 (d) 12 kg·m^2 (e) 16 kg·m^2

19. A 0.10-kg block is held in place by a force $\vec{F}$ that results in a 0.10-m compression of a spring beneath the block. The spring constant is 1.0×10^2 N/m. Assuming the mass of the spring is negligible compared to that of the block, to what maximum height would the block rise if the force $\vec{F}$ were removed?

(a) 0.26 m
(b) 0.51 m
(c) 1.0 m
(d) 2.1 m
(e) 5 m



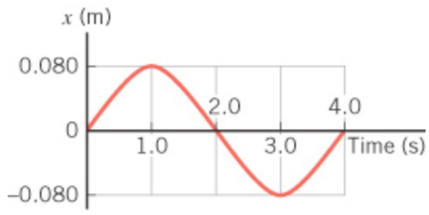
20. A simple pendulum consists of a ball of mass *m* suspended from the ceiling using a string of length *L*. The ball is displaced from its equilibrium position by a small angle θ. What is the magnitude of the restoring force that moves the ball toward its equilibrium position and produces oscillation?

(a) kx (b) mg (c) $mg(\cos\theta)$ (d) $mg(\sin\theta)$ (e) $mgL(\sin\theta)$

21. When a force of 10 N is applied to a spring, it elongates 45 mm. Determine the period of oscillation of a 4.0-kg object suspended from this spring.

(a) 0.84 s (b) 1.2 s (c) 3.1 s (d) 4.1 s (e) 6.3 s

22. A 2.0-kg block oscillates on the end of a massless spring. The resulting simple harmonic motion is shown in the drawing. What is the potential energy of the block at $t = 1.0$ s?



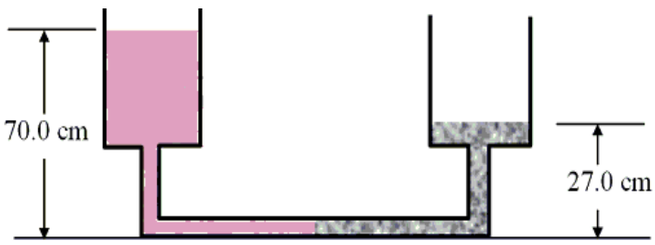
(a) 0.016 J (b) 4.0 J (c) 13 J
(d) 0.72 J (e) n.o.t.

23. A 101-kg bar of aluminum (density 2700 kg/m^3) rests on the bottom of a tank filled with an unknown liquid, 0.25 m below the surface. The apparent weight of the bar is 601 N. What is the density of the liquid?

(a) 2700 kg/m^3 (b) 1060 kg/m^3 (c) 1000 kg/m^3 (d) 840 kg/m^3 (e) n.o.t.

24. A column of oil of height 70.0 cm supports a column of an unknown liquid as suggested in the figure (not drawn to scale). Assume that both liquids are at rest and that the density of the oil is 840 kg/m^3. Determine the density of the unknown liquid.

(a) 3.2×10^2 kg/m^3
(b) 2.2×10^3 kg/m^3
(c) 2.6×10^3 kg/m^3
(d) 3.6×10^3 kg/m^3
(e) 4.9×10^3 kg/m^3

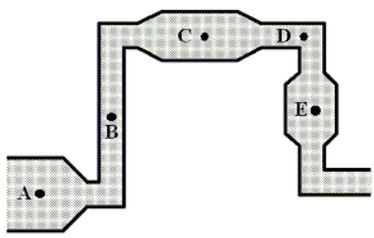


25. Selena uses a garden hose to fill a bucket of water. The water enters the hose through a faucet with a 6.0-cm diameter. The speed of the water at the faucet is 5 m/s. If the faucet and the nozzle are at the same height, and the water leaves the nozzle with a speed of 20 m/s, what is the diameter of the nozzle?

(a) 1.0 cm (b) 2.0 cm (c) 3.0 cm (d) 4.0 cm (e) 6.0 cm

26. A horizontal piping system that delivers a constant flow of water is constructed from pipes with different diameters as shown in the figure. At which of the labeled points is the water in the pipe under the greatest pressure? The drawing is a view from above the pipe.

(a) **A**
(b) **B**
(c) **C**
(d) **D**
(e) **E**



27. A metal rod 40.0000-cm long at 55.0 °C is heated to 85.0 °C. The length of the rod is then measured to be 40.0264 cm. What is the coefficient of linear expansion of the metal?

(a) 13×10^{-6}/C° (b) 22×10^{-6}/C° (c) 44×10^{-6}/C°
(d) 53×10^{-6}/C° (c) 71×10^{-6}/C°

28. An aluminum tank of volume 10.000 L is filled to the top with mercury at 25.0 °C. The tank is placed inside a chamber with an interior temperature maintained at 85.0 °C. The coefficient of volume expansion for mercury is 1.82×10^{-4}/C°; and the coefficient of linear expansion of aluminum is 23.0×10^{-6}/C°. After the tank and its contents reach thermal equilibrium with the interior of the chamber, how much mercury has spilled? Ignore surface tension.

(a) 24 mL (b) 68 mL (c) 91 mL (d) 117 mL (e) 1.3 L

29. A 2.0-g sample of steam at 100 ºC loses 140 calories of heat. What is the resulting temperature of the sample?

(a) 60 ºC (b) 70 ºC (c) 80 ºC (d) 99 ºC (e) 100 ºC

30. If 0.150 kg of boiling water is placed in a thermos bottle, how many kilograms of ice at -12.0 ºC must be added to the thermos so that the equilibrium temperature of the water is 75.0 ºC? Neglect heat exchange with the container or the environment.

(a) 0.0233 kg (b) 0.0265 kg (c) 0.0436 kg (d) 0.0713 kg (e) 0.625 kg

THE END

Answers:

1. D	11. C	21. A
2. C	12. C	22. A
3. D	13. D	23. B
4. C	14. D	24. B
5. D	15. A	25. C
6. A	16. D	26. A
7. C	17. E	27. B
8. A	18. E	28. B
9. D	19. B	29. E
10. B	20. D	30. A