EXAMINERS: W. Ens, J. English, C. O'Dea, J. Mammei

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

$G = 6.674 \times 10^{-11}\ \text{m}^3\text{kg}^{-1}\text{s}^{-2}$	Standard atmospheric pressure = 1.013×10^5 Pa
$g = 9.80\ \text{m/s}^2$	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 C°)
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

1. A certain physical quantity, R, is calculated using the formula: $R = 4a^2(b - c)$ 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 begins accelerating with a constant acceleration of 1.5 m/s^2 in the direction of motion. After traveling 392 m at this acceleration, its speed is 35 m/s. Determine the speed of the car when it began accelerating.

(a) 1.5 m/s (b) 7.0 m/s (c) 34 m/s (d) 49 m/s (e) 2.3 m/s

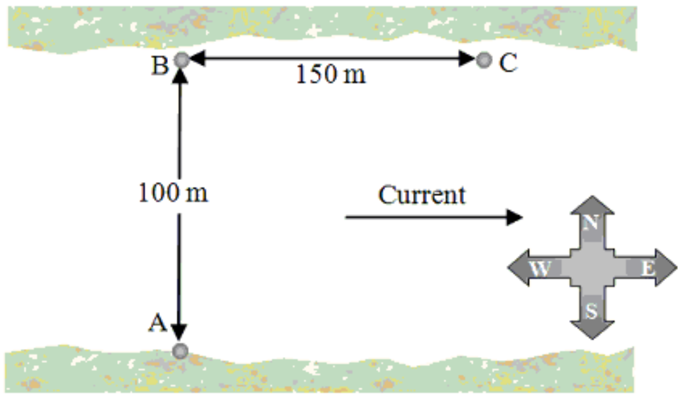
3. A brick is dropped from rest from a height of 4.9 m. How long does it take the brick to reach the ground?

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

4. A projectile is fired at an angle of 55.0° above the horizontal with an initial speed of 35.0 m/s. How long does it take the projectile to reach the highest point in its trajectory?

(a) 1.5 s (b) 2.9 s (c) 4.0 s (d) 6.2 s (e) 9.8 s

5. A man at point A directs his rowboat due north toward point B, straight across a river of width 100 m. The river current is due east. The man starts across, rowing steadily at 0.75 m/s and reaches the other side of the river at point C, 150 m downstream from his starting point.



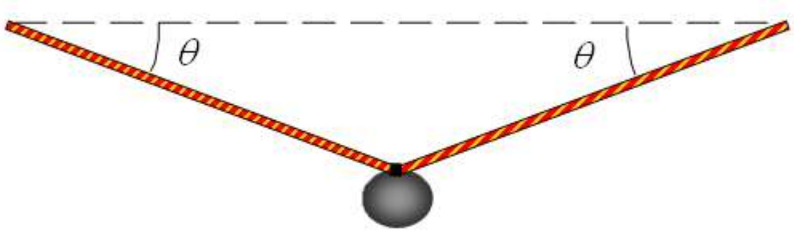
While the man is crossing the river, what is his velocity relative to the shore?

(a) 1.35 m/s, 34° north of east
(b) 2.00 m/s, 56° north of east
(c) 1.74 m/s, 34° north of east
(d) 2.11 m/s, 34° north of east
(e) 2.50 m/s, 42° north of east

6. A crate rests on the flatbed of a truck that is initially traveling at 15 m/s on a level road. The driver applies the brakes and the truck is brought to a halt in a distance of 38 m. If the deceleration of the truck is constant, what is the minimum coefficient of friction between the crate and the truck that is required to keep the crate from sliding?

(a) 0.20 (b) 0.30 (c) 0.39 (d) 0.59
(e) This cannot be determined without knowing the mass of the crate.

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

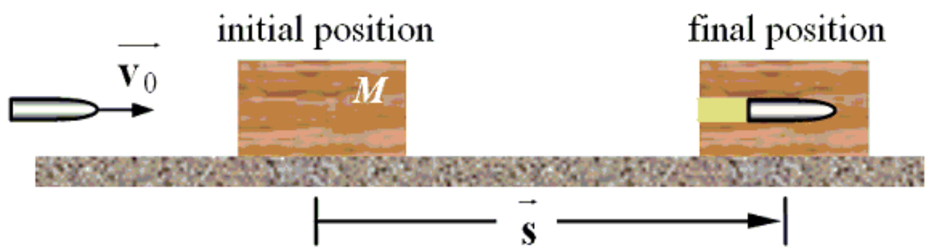
8. A certain string breaks when it is under 25 N of tension. A boy uses this string to whirl a 0.75-kg stone in a horizontal circle of radius 2.0 m. The boy continuously increases the speed of the stone. At approximately what speed will the string break?

(a) 6.4 m/s (b) 8.0 m/s (c) 12 m/s (d) 15 m/s (e) 18 m/s

9. Jupiter has a mass that is roughly 320 times that of the Earth and a radius equal to 11 times that of the Earth. What is the acceleration due to gravity on the surface of Jupiter?

(a) 2.7 m/s^2 (b) 9.8 m/s^2 (c) 26 m/s^2 (d) 87 m/s^2 (e) 260 m/s^2

10. 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) $s = \dfrac{v_0^2}{\mu g}$

11. A 51-kg woman runs up a flight of stairs in 5.0 s. Her net upward displacement is 5.0 m. Approximately, what average power did the woman exert while she was running?

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

12. A 0.065-kg tennis ball moving to the right with a speed of 15 m/s is struck by a tennis racket, causing it to move to the left with a speed of 15 m/s. If the ball remains in contact with the racquet for 0.020 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 600 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) 50 m (d) 100 m (e) 500 m

15. A spinning disc rotating at 130 rev/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

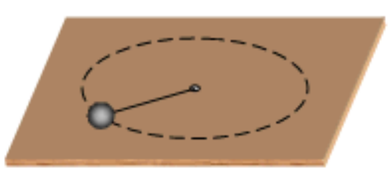
16. A long thin rod of length $2L$ rotates with a constant angular acceleration of 8.0 rad/s^2 about an axis that is perpendicular to the rod and passes through its center. What is the ratio of the tangential speed (at any instant) of a point on the end of the rod to that of a point a distance $L/2$ from the end of the rod?

(a) 1:1 (b) 1:2 (c) 2:1 (d) 4:1 (e) 1:4

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-half its initial value. What is the skater's final angular speed?

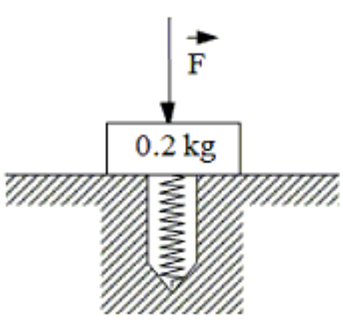
(a) 3.0 rad/s (b) 4.5 rad/s (c) 9.0 rad/s (d) 12 rad/s (e) 18 rad/s

18. A ball of mass M moves in a circular path on a horizontal, frictionless surface. It is attached to a light string that passes through a hole in the center of the table. If the string is pulled down, thereby reducing the radius of the path of the ball, the speed of the ball is observed to increase. Complete the following sentence: This occurs because



(a) the linear momentum of the ball is conserved.
(b) it is required by Newton's first law of motion.
(c) the angular momentum of the ball is conserved.
(d) the angular momentum of the ball must increase.
(e) the total mechanical energy of the ball must remain constant.

19. A 0.2-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) 0.52 m
(c) 2.5 m
(d) 5 m
(e) 10 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 simple harmonic motion?

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

21. When a force of 19 N is applied to a spring, it elongates 0.085 m. 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

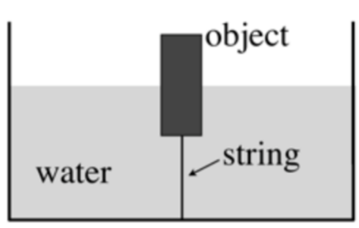
22. A column of oil of height 70.0 cm supports a column of an unknown liquid as suggested in the figure (not drawn to scale). Assume that both liquids are at rest and that the density of the oil is 840 kg/m^3. Determine the density of the unknown liquid.

(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

23. In a car lift, compressed air with a gauge pressure of 4.0×10^5 Pa is used to raise a piston with a circular cross-sectional area. If the radius of the piston is 0.17 m, what is the maximum mass that can be raised using this piston?

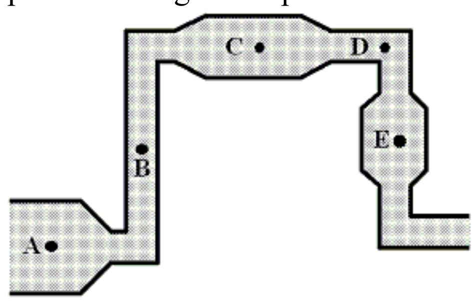
(a) 530 kg (b) 3700 kg (c) 9800 kg (d) 22 000 kg (e) 41 000 kg

24. A 2-kg block is tied down as shown in the figure, and it displaces 5 liters of water. What is the tension in the string?



(a) 10 N
(b) 20 N
(c) 30 N
(d) 70 N
(e) 100 N

25. 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**

26. An aluminum plate has a length of 0.12 m and a width of 0.10 m at 25 ºC. The plate is uniformly heated to 225 ºC. If the linear expansion coefficient for aluminum is 2.3×10^{-5}/Cº, what is the *change* in the area of the plate as a result of the increase in temperature?

(a) 1.1×10^{-4} m^2 (b) 6.1×10^{-4} m^2 (c) 3.2×10^{-5} m^2
(d) 4.9×10^{-6} m^2 (e) 7.8×10^{-6} m^2

27. A gold sphere has a radius of 1.000 cm at 25.0 ºC. If 7650 J of heat is added to the sphere, what will the final volume of the sphere be? Gold has a density of 19 300 kg/m^3 at 25.0 ºC, a specific heat capacity of 129 J/(kg·Cº), and a coefficient of volume expansion of 42.0 × 10^{-6}/Cº. The volume of a sphere is $\frac{4}{3}\pi r^3$.

(a) 2.88 × 10^{-6} m^3 (b) 3.01 × 10^{-6} m^3 (c) 3.33 × 10^{-6} m^3
(d) 3.91 × 10^{-6} m^3 (e) 4.32 × 10^{-6} m^3

28. A 2.0-g sample of steam at 100 ºC loses 1140 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

29. An ideal gas is contained in a vessel with a moveable piston. Initially, the gas has a volume of 0.024 m^3, an absolute pressure of 1.8 atm, and a temperature of 35.0 ºC. The pressure is 0.90 atm when the volume of the container is decreased to 0.012 m^3. What is the final temperature of the gas?

(a) -196 ºC (b) -188 ºC (c) -103 ºC (d) 8.8 ºC (e) 140 ºC

30. Consider two ideal gases, **A** and **B**, at the same temperature. The *rms* speed of the molecules of gas **A** is twice that of gas **B**. How does the molecular mass of **A** compare to that of **B**?

(a) The molecular mass of **A** is twice that of **B**.
(b) The molecular mass of **A** is one half that of **B**.
(c) The molecular mass of **A** is 1.4 times that of **B**.
(d) The molecular mass of **A** is one fourth that of **B**.
(e) The molecular mass of **A** is four times that of **B**.

THE END

ANSWERS:

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