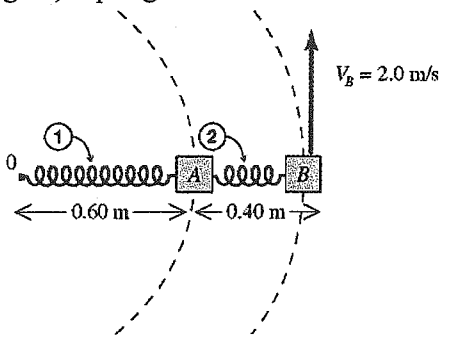
請在答案卡作答

單選題共 25 題，每題 4 分，答錯不倒扣。

1. What is the value of $\pi(8.104)^2$, written with the correct number of significant figures?
(A) 206.324, (B) 206.323, (C) 206.3, (D) 206, (E) 200.

2. Block *A* (0.40 kg) and block *B* (0.30 kg) are on a frictionless table (see figure). Spring 1 connects block *A* to a frictionless peg at *O* and spring 2 connects block *A* and block *B*. When the blocks are in uniform circular motion about *O*, the springs have lengths of 0.60 m and 0.40 m, as shown. The springs are ideal and massless, and the linear speed of block *B* is 2.0 m/s. If the spring constant of spring 1 is equal to 30 N/m, the unstretched length of spring 1 is closest to
(A) 0.51 m, (B)0.53 m, (C) 0.55 m, (D) 0.54 m, (E) 0.52 m.



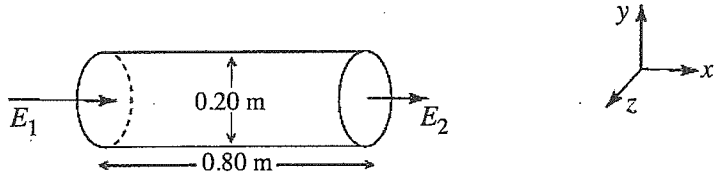
3. Two optically flat glass plates, 16.0 cm long, are in contact at one end and separated by 0.0200 mm at the other end. The space between the plates is occupied by oil with index of refraction 1.45. The index of refraction of the glass plates is 1.55. The plates are illuminated at normal incidence with monochromatic light, and fringes are observed. If the dark fringes are spaced 2.00 mm apart, what is the wavelength of the monochromatic light?
(A) 475 nm, (B) 425 nm, (C) 525 nm, (D) 675 nm, (E) 725 nm.

4. Ekapluto is an unknown planet that has two moons in circular orbits. The table summarizes the hypothetical data about the moons. ($G = 6.67 \times 10^{-11}$ N · m^2/kg^2)

	Mass	*Radius*	*Orbital radius*	*Orbital period*
Moon A	4.0×10^{20} kg		2.0×10^{8} m	4.0×10^{6} s
Moon B	1.5×10^{20} kg	2.0×10^{5} m	3.0×10^{8} m	

The mass of Ekapluto is closest to
(A)1.0×10^{23} kg, (B) 3.0×10^{23} kg, (C) 1.0×10^{24} kg, (D) 1.0×10^{22} kg, (E) 3.0×10^{22} kg.

5. A nonuniform electric field is directed along the *x*-axis at all points in space. This magnitude of the field varies with *x*, but not with respect to *y* or *z*. The axis of a cylindrical surface, 0.80 m long and 0.20 m in diameter, is aligned parallel to the *x*-axis, as shown in the figure. The electric fields E_1 and E_2, at the ends of the cylindrical surface, have magnitudes of 9000 N/C and 5000 N/C respectively, and are directed as shown. ($\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/N · m^2) The charge enclosed by the cylindrical surface is closest to



(A) -2.4 nC. (B) -4.8 nC. (C) -1.1 nC. (D) 4.8 nC. (E) 1.1 nC.

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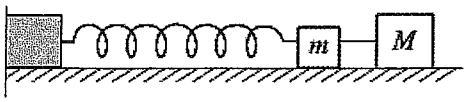
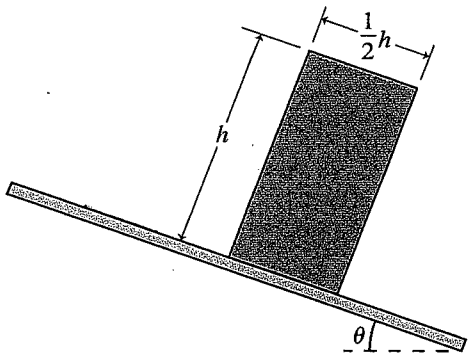
6. In the figure, two masses, $M = 16$ kg and $m = 12.80$ kg, are connected to a very light rigid bar and are attached to an ideal massless spring of spring constant 100 N/m. The system is set into oscillation with an amplitude of 78 cm. At the instant when the acceleration is at its maximum, the 16-kg mass separates from the 12.80-kg mass, which then remains attached to the spring and continues to oscillate. What will be the amplitude of oscillation of the 12.80-kg mass?



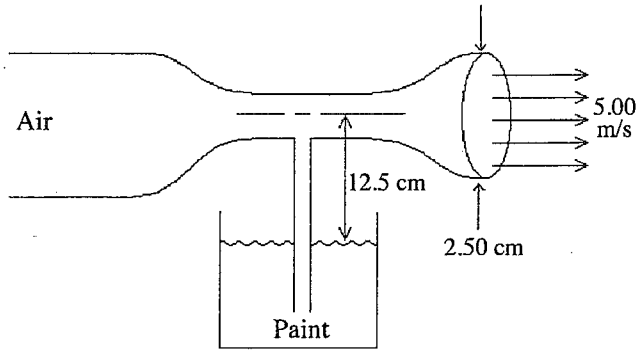
(A) 35 cm, (B) 62 cm, (C) 98 cm, (D) 78 cm, (E) 180 cm.

7. A rectangular block twice as high as it is wide is resting on a board. The coefficient of static friction between board and incline is 0.46. If the board's incline angle is gradually increased,



(A) the block will first tip over than slide.
(B) the block will first slide than tip over.
(C) will the block first tip over or begin sliding depends on its moment of inertia.
(D) will the block first tip over or first begin sliding depends on the coefficient of kinetic friction between board and incline.
(E) None of the above.

8. A paint sprayer pumps air through a constriction in a 2.50-cm diameter pipe, as shown in the figure. The flow causes the pressure in the constricted area to drop and paint rises up the feed tube and enters the air stream. The speed of the air stream in the 2.50-cm diameter sections is 5.00 m/s. The density of the air is 1.29 kg/m^3, and the density of the paint is 1200 kg/m^3. We can treat the air and paint as incompressible ideal fluids. What is the maximum diameter of the constriction that will allow the sprayer to operate?



(A) 12.2 mm, (B) 9.65 mm, (C) 14.3 mm, (D) 4.05 mm, (E) 8.07 mm.

9. A hot piece of iron is thrown into the ocean and its temperature eventually stabilizes. Which of the following statements concerning this process is correct?
(A) The ocean gains less entropy than the iron loses.
(B) The change in the entropy of the iron-ocean system is zero.
(C) The entropy lost by the iron is equal to the entropy gained by the ocean.

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(D) The entropy gained by the iron is equal to the entropy lost by the ocean.

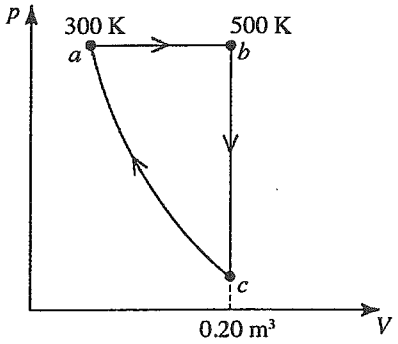
(E) The ocean gains more entropy than the iron loses.

10. A spaceship approaches the earth with a speed 0.50*c*. A passenger in the spaceship measures his heartbeat as 70 beats per minute. What is his heartbeat rate (beats per minute) according to an observer that is at rest relative to the earth?

(A) 69, (B) 73, (C) 80, (D) 65, (E) 61.

11. A heat engine performs the reversible cycle *abca* with 9.0 moles of an ideal gas, as shown in the figure. Path *ca* is an adiabatic process. The temperatures at points *a* and *b* are 300 K and 500 K, respectively. The volume at point *c* is 0.20 m^3. The adiabatic constant of the gas is 1.60. The thermal efficiency of this engine is closest to

(A) 0.13, (B) 0.10, (C) 0.16, (D) 0.07, (E) 0.19.



12. A cylinder contains 1.2 moles of ideal gas, initially at a temperature of 116°C. The cylinder is provided with a frictionless piston, which maintains a constant pressure of 6.4×10^5 Pa on the gas. The gas is cooled until its temperature has decreased to 27°C. For the gas $C_V = 11.65$ J/mol · K, and the ideal gas constant $R = 8.314$ J/mol · K.

(A) The work done by the gas during this process is 890 J.

(B) The work done on the gas during this process is 890 J.

(C) The change in the internal (thermal) energy of the gas during this process is +1200 J.

(D) The heat transferred from the gas during this process is -1200 J.

(E) The heat transferred to the gas during this process is +2100 J.

13. A certain particle's energy is measured by a detector to within 1.0×10^{-18} J. What is the minimum uncertainty we can have in its arrival time at the detector? (Plank constant, $h = 6.626 \times 10^{-34}$ J · s)

(A) 1.1×10^{-12}s, (B) 1.1×10^{-16} s, (C) 1.1×10^{-15}s, (D) 1.1×10^{-13}s, (E) 1.1×10^{-14}s.

14. The wave function for a particle must be normalizable because

(A) the particle must be somewhere.

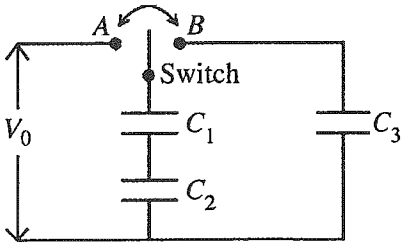
(B) the particle's angular momentum must be conserved.

(C) the particle's charge must be conserved.

(D) the particle's momentum must be conserved.

(E) the particle cannot be in two places at the same time.

15. In the circuit shown in the figure, the capacitors are initially uncharged. The switch is first thrown to position *A* and kept there for a long time. It is then thrown to position *B*. Let the charges on



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the capacitors be Q_1, Q_2, and Q_3 and the potential differences across them be V_1, V_2, and V_3. Which of the following conditions must be true with the switch in position B?

(A) $Q_1 = Q_2 = Q_3$, *(B)* $V_1 = V_2 = V_3$, *(C)* $V_1 + V_2 = V_3$, *(D)* $Q_1 + Q_2 = Q_3$, *(E)* $V_3 = V_0$

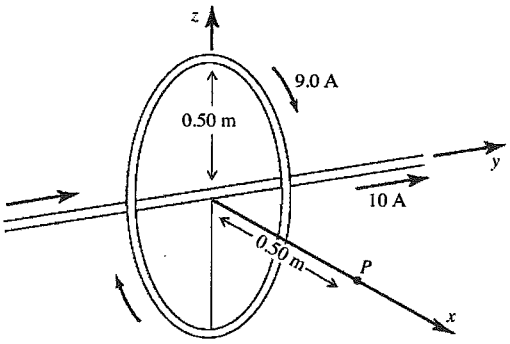
16. Two long conducting cylindrical shells are coaxial and have radii of 20 mm and 80 mm. The electric potential of the inner conductor, with respect to the outer conductor, is +600 V. What is the maximum electric field magnitude between the cylinders? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N · m^2/C^2)

(A) 22,000 V/m, (B) 18,000 V/m, (C) 10,000 V/m, (D) 14,000 V/m, (E) 26,000 V/m.

17. In a certain region, the electric potential due to a charge distribution is given by the equation $V(x,y) = 2xy - x^2 - y$, where x and y are measured in meters and V is in volts. At which point is the electric field equal to zero?

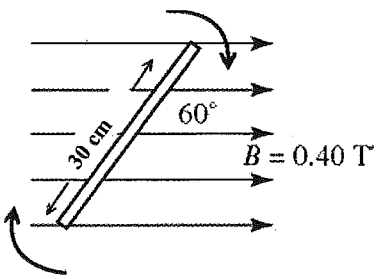
(A) $x = 0.5$ m, $y = 0.5$ m
(B) $x = 0$ m, $y = 0$ m
(C) $x = 1$ m, $y = 1$ m
(D) $x = 0.5$ m, $y = 1$ m
(E) $x = 1$ m, $y = 0.5$ m

18. A long straight very thin wire on the y-axis carries a 10-A current in the positive y-direction. A circular loop 0.50 m in radius, also of very thin wire and lying in the yz-plane, carries a 9.0-A current, as shown. Point P is on the positive x-axis, at a distance of 0.50 m from the center of the loop. What is the magnetic field vector at point P due to these two currents? ($\mu_0 = 4\pi \times 10^{-7}$ T m/A)



(A) zero
(B) -8.0×10^{-6} T $\boldsymbol{k}$
(C) $(+4.0 \times 10^{-6}$ T$)\,\boldsymbol{i} - (4.0 \times 10^{-6}$ T$)\,\boldsymbol{k}$
(D) $(-8.0 \times 10^{-6}$ T$)\,\boldsymbol{i} - (8.0 \times 10^{-6}$ T$)\,\boldsymbol{k}$
(E) $(-4.0 \times 10^{-6}$ T$)\,\boldsymbol{i} - (4.0 \times 10^{-6}$ T$)\,\boldsymbol{k}$

19. Wire is wound on a square frame, 30 cm by 30 cm, to form a coil of 7 turns. The frame is mounted on a horizontal shaft through its center (perpendicular to the plane of the diagram), as shown in the figure. The coil is in clockwise rotation, with a period of 0.060 s. A uniform, horizontal, magnetic field of magnitude 0.40 T is present. At a given instant, the plane of the coil forms a 60° angle with the horizontal, as shown. At that instant, what is the magnitude of the emf induced in the coil?



(A) 2.1 V, (B) 23 V, (C) 26 V, (D) 3.6 V, (E) 13 V.

20. An LRC series circuit has $R = 15.0\ \Omega$, $L = 25.0$ mH, and $C = 30.0\ \mu$F. The circuit is connected to a 120-V (rms) ac source with frequency 200 Hz.

(A) The impedance of the circuit is 163 Ω,

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(B) The rms current in the circuit is 7.16 A,

(C) The rms voltage across the resistor is 110V,

(D) The rms voltage across the inductor is 239 V,

(E) The rms voltage across the capacitor is 123 V

21. Some properties of glass are listed here.

Density: 2300 kg/m^3

Specific heat: 840 J/kg·C°

Coefficient of linear thermal expansion: 8.5×10^{-6} (C°)$^{-1}$

Thermal conductivity: 0.80 W/(m·C°)

A glass window pane is 2.7 m high, 2.4 m wide, and 2.0 mm thick. The temperature at the inner surface of the glass is 22°C and at the outer surface 4.0°C. How much heat is lost each hour through the window under steady state conditions?

(A) 1.7×10^8 J, (B) 4.7×10^4 J, (C) 1.7×10^6 J, (D) 1.7×10^5 J, (E) 4.7×10^1 J.

22. When an electromagnetic wave falls on a white, perfectly reflecting surface, it exerts a force F on that surface. If the surface is now painted a perfectly absorbing black, what will be the force that the same wave will exert on the surface?

(A) $F/2$, (B) F, (C) $F/4$, (D) $4F$, (E) $2F$.

23. A microwave oven operates with sinusoidal microwaves at a frequency of 2400 MHz. The height of the oven cavity is 25 cm and the base measures 30 cm by 30 cm. Assume that microwave energy is generated uniformly on the upper surface of the cavity and propagates directly downward toward the base. The base is lined with a material that completely absorbs microwave energy. The total microwave energy content of the cavity is 0.50 μJ. What is the amplitude of the electric field? ($c = 3.00 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/N m^2)

(A) 2500 V/m, (B) 1900 V/m, (C) 2200 V/m, (D) 2800 V/m, (E) 1600 V/m.

24. A 1.0-kg block and a 2.0-kg block are pressed together on a horizontal frictionless surface with a compressed very light spring between them. They are not attached to the spring. After they are released and have both moved free of the spring

(A) both blocks will have equal speeds.

(B) the magnitude of the momentum of the heavier block will be greater than the magnitude of the momentum of the lighter block.

(C) the lighter block will have more kinetic energy than the heavier block.

(D) the heavier block will have more kinetic energy than the lighter block.

(E) both blocks will both have the same amount of kinetic energy.

25. You need 14 W of infrared laser light power with wavelength 1270 nm to bore a hole in a diamond. How many downward atomic transitions per second must occur in the laser if all of them result in light directed onto the diamond? ($c = 3.00 \times 10^8$ m/s, $h = 6.626 \times 10^{-34}$ J · s)

(A) 2.7×10^{18}, (B) 8.9×10^{19}, (C) 9.8×10^{18}, (D) 5.9×10^{19}, (E) 1.4×10^{18}.