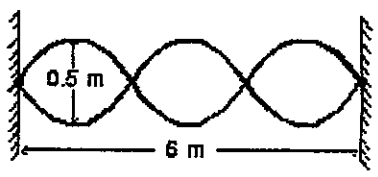
※ 注意：請於試卷上「非選擇題作答區」標明題號並依序作答。

1. During a rockslide, a 200 kg rock slides from rest down a hillside that is 500 m long and 300 m high. The coefficient of kinetic friction between the rock and the hill surface is 0.25. What is the speed of the rock as it reaches the bottom of the hill? How long does it take for sliding down this 500 m path? (10 %)

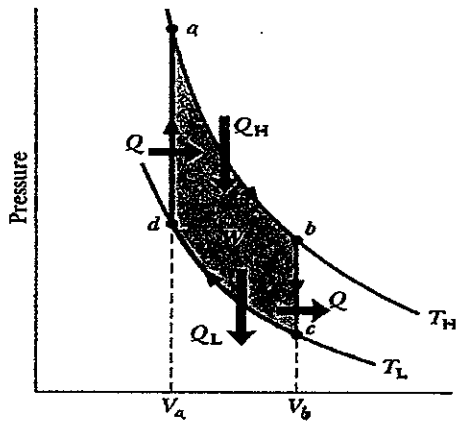
2. The rotational inertia of a collapsing spinning star drops to ¼ its initial value. What is the ratio of the new rotational kinetic energy to the initial rotational kinetic energy? Explain the source for the increase of rotational kinetic energy. (10%)

3. Write down the equation of motion for a damped simple harmonic oscillator oscillating along the x axis with mass m, spring constant k, and a damping term bv, where v is its velocity. Solve this equation to find out its solution in terms of the above information. Use t to denote time, A for amplitude, and φ for the initial phase in your answer. (10%)

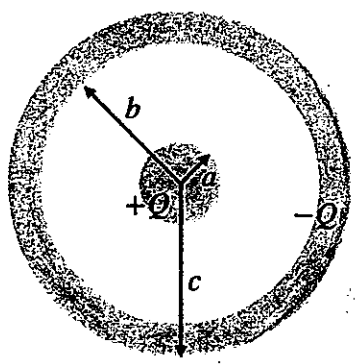
4. Write down the functional form $y(x,t)$ of a standing wave with a frequency of 5.0 Hz and an amplitude of 0.25 m, shown in the right figure. What's the total energy of this standing wave assuming the linear density of this string is 0.0010 kg/m? (10%)



5. For an ideal Stirling engine, find out the absorbed heat and entropy change in the isochoric process $(V_a, P_d) \rightarrow (V_a, P_a)$ of a full cycle as shown in the right figure, assuming the system contains one mole mono-atomic ideal gas. You should use R to denote the universal gas constant in your answers. (10%)



6. A conductor ball with radius a carries a net charge $+Q$. It is placed at the center of another spherical conductor with inner-radius b and outer-radius c. The conductor sphere carries a net charge $-Q$. **(a)** How would the charge distribute on the sphere? Provide quantitative theory for your answer. (5%) **(b)** If one thinks of this system as a capacitor, what would be the capacitance? Show your calculation explicitly. (5%)



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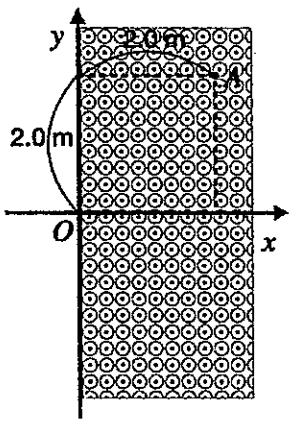
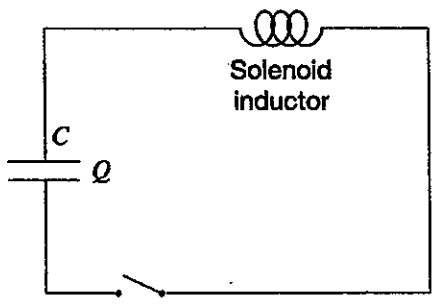
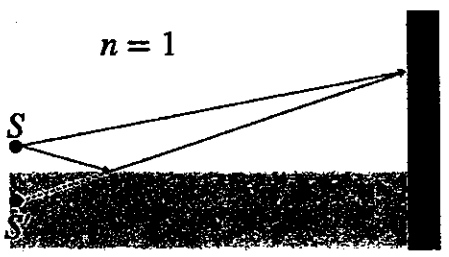
7. As shown in the figure, there is a homogeneous magnetic field pointing to the positive z direction in the region $x > 0$. An electron enters the magnetic field at point O with a velocity pointing along the $+x$ direction. 0.63 microseconds later, it arrives at point A. **(a)** What is the direction of the electron's velocity when it reaches A? Provide quantitative arguments for your answer. (5%) **(b)** What is the magnitude of the magnetic field? Show your calculation explicitly. (5%)



8. A student found a solenoid inductor made of thick resistive metal wire in the lab. This inductor is connected serially to a capacitor, initially charged with charge Q. When the switch is shorted, the decay of the charge on the capacitor is monitored and the time constant is determined to be τ. Next, the student unrolled the solenoid and stretched the metal wire homogeneously so that it became twice as long as it used to be. Then the student made a new solenoid with the stetched wire. The radius of the solenoid is the same as before, only the number of turns is changed. **(a)** How are the inductance and resistance of the solenoid changed? Provide your reason. (5%) **(b)** The same experiment monitorring the discharge kinetics is repeated with the same capacitor and the new inductor. How would the time constant change? Provide your reason. (5%)



9. To study the interference of two beams, instead of using two slits, one can use one light source and a reflecting surface to construct an interferometer, as shown in the figure. Suppose that the incidence angle is always big enough to assume that the intensities of the direct beam and reflected beam are very close to each other. **(a)** If the reflecting mirror is a piece of glass with index of refraction $n > 1$, how would the interference pattern differ, qualitatively, from double-slit interference pattern with the same separation between the two sources? What is the reason for the difference? (5%) **(b)** If the mirror is made of highly conductive metal such as copper or gold, how would the interference pattern differ from that of the previous case? Provide your reason. (5%)



10. One of the key concepts in the quantum theory is the manifestation of wave-particle duality of matter in the microscopic world. In other words, a microscopic particle, such as an electron, demonstrates particle-like behavior in some circumstances and wave-like behavior in other situation. **(a)** What are the particle-like properties, and what are the wave-like properties? Explain briefly by making comparison between them. (5%) **(b)** Which physical quantities are used to describe the kinetic properties (that is, properties of its motion) of a particle? And which physical quantities are used to describe the kinetic properties of a wave? How are they connected in quantum theory? (5%)

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