※ 考生請注意：本試題不可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

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**Some useful constants**

Gas constant $R = 8.314\,J/mol \cdot K$　　　　Gravitational constant $G = 6.68 \times 10^{-11}N \cdot m^2/kg^2$

Mass of Sun $= 2.0 \times 10^{30}kg$　　　　　　Mass of Earth $= 6.0 \times 10^{24}kg$

Radius of Sun $= 7.0 \times 10^8 m$　　　　　　Radius of Earth $= 6.4 \times 10^6 m$

Electron mass $m_e = 9.1 \times 10^{-31}kg$　　　Electron charge $e = 1.6 \times 10^{-19}C$

Electric constant (permittivity) $\epsilon_0 = 8.85 \times 10^{-12}C^2/N \cdot m^2$

Magnetic constant (permeability) $\mu_0 = 4\pi \times 10^{-7}T \cdot m/A$

Planck's constant $h = 6.63 \times 10^{-34}J \cdot s$　　　　$1eV = 1.6 \times 10^{-19}J$

Boltzmann constant $k_B = 1.38 \times 10^{-23}J \cdot K^{-1}$

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第一部分 ： 簡答題(60 分)。
共 12 題，每題 5 分，請在答案卷上標明題號並依續作答(中英文作答均可，無須詳列計算過程)。

1. A single force acts on a 3.0 kg particle-like object whose position is given by $x = 3.0t - 4.0t^2 + 1.0t^3$, with $x$ in meters and $t$ in seconds. Find the work done by the force from $t = 0$ to $t = 4.0$ s.

2. What horizontal force must be applied to a large block of mass $M$ shown in the figure so that the small blocks remain stationary relative to $M$? Assume all surfaces and the pulley are frictionless.
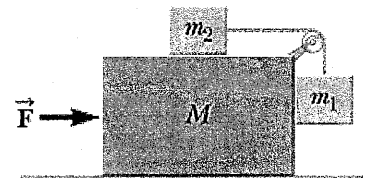


3. The puck in the Figure has a mass of 0.120 kg. The distance of the puck from the center of rotation is originally 40.0 cm, and the luck is sliding with a speed of 80.0 cm/s. The string is pulled downward 15.0 cm through the hole in the frictionless table. Determine the work done on the puck.
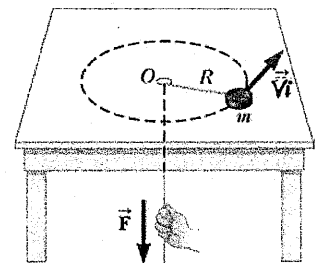


4. A uniform rod of mass $M$ and length $L$ is pivoted about one end and oscillates in a vertical plane. Find the period of oscillation if the amplitude of the motion is small.

5. A taut string for which $\mu = 5.00 \times 10^{-2}$ kg/m is under a tension of 80.0 N. How much power must be supplied to the string to generate sinusoidal waves at a frequency of 60.0 Hz and an amplitude of 6.00 cm?

6. A 0.500-mol sample of hydrogen gas is at 300 K. Find the root-mean-square speed of the $H_2$ molecules.

7. A cooper wire has a cross-sectional area of $3.31 \times 10^{-6}$ m$^2$. It carries a constant current of 10.0 A. What is the drift speed of the electrons in the wire? Assume each cooper atom contributes one free electron to the current. The density of copper is 8.92 g/cm$^3$.

8. The conducting bar illustrated in the figure moves on two frictionless, parallel rails in the presence of a uniform magnetic field directed into the page. The bar has mass $m$, and its length is $l$. The bar is given an initial velocity $\vec{v_i}$ to the right and is released at $t = 0$. Find the speed of the bar as a function of time after it is released.
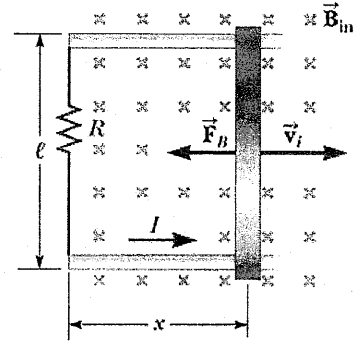
9. The intensity of sunlight at the Earth's distance from the Sun is 1370 W/m$^2$. Assume the Earth absorbs all the sunlight incident upon it. Find the total force the Sun exerts on the Earth due to radiation pressure.

10. What is the approximate size of the smallest object on the Earth that astronauts can resolve by eye when they are orbiting 250 km above the Earth? Assume $\lambda = 500$ nm and a pupil diameter of 5.00 mm.

11. The $J = 0$ to $J = 1$ rotational transition of the CO molecule occurs at a frequency of $1.15 \times 10^{11}$ Hz. Use this information to calculate the moment of inertia of the molecule.

12. For the nuclear force to overcome the repulsive Coulomb force, the separation distance between the two deuterons must be approximately $1.0 \times 10^{-14}$ m. Estimate the temperature required for a deuteron to overcome the potential barrier, assuming an energy of $\frac{3}{2} k_B T$ per deuteron (where $k_B$ is Boltzmann's constant).

第二部分 ： 計算題(40 分)

共 3 題，請在答案卷上標明題號依續作答，並詳列計算過程（中英文作答均可）。

1. A cylinder with adiabatic walls is closed at both ends and is divided into two volumes by a frictionless piston that is also thermally insulating. Initially, the volume, pressure and temperature of the ideal gas in each side of the cylinder are equal at $V_0, P_0$ and $T_0$ respectively. A heating coil in the right-hand volume is used to heat slowly the gas on that side until the pressure reaches $64P_0/27$. If the heat capacity $C_V$ of the gas is independent of temperature, and $C_P/C_V = \gamma = 1.5$,　find the following in terms of $V_0, P_0$ and $T_0$:

   (a) the entropy change of the gas on the left; **(5 points)**

   (b) the final left-hand volume; **(5 points)**

(c) the final left-hand temperature; **(5 points)**

(d) the work done on the gas on the left. **(5 points)**

2. A capacitor is constructed from two square, metallic plates of sides $l$ and separation $d$. Charges $+Q$ and $-Q$ are placed on the plates, and the power supply is then removed. A material of dielectric constant $\kappa$ is inserted a distance $x$ into the capacitor as shown in the Figure. Assume $d$ is much smaller than $x$.
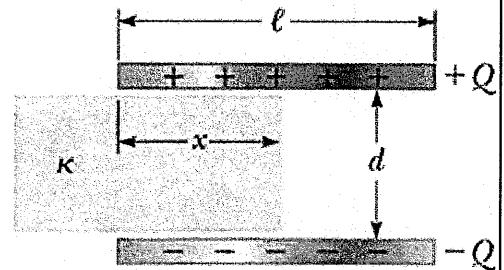
(a) Calculate the energy stored in the capacitor. **(5 points)**

(b) Find the direction and magnitude of the force exerted by the plates on the dielectric. **(5 points)**

3. A series $RLC$ circuit has $R = 425\ \Omega$, $L = 1.25\ H$, and $C = 3.50\ \mu F$. It is connected to an AC source with $f = 60.0\ Hz$ and $\Delta V_{max} = 150\ V$.

(a) Determine the impedance of the circuit. **(5 points)**

(b) Calculate the average power delivered to the series $RLC$ circuit. **(5 points)**