# 臺灣綜合大學系統 114 學年度學士班轉學生聯合招生考試試題

| 科目名稱 | 普通物理 B | 類組代碼 | 共同考科 |
|---|---|---|---|
| | | 科目碼 | E0015 |

※本項考試依簡章規定所有考科均「不可」使用計算機。　　本科試題共計 5 頁

Some useful constants

Gas constant $R = 8.314$ J/mol·K

Gravitational constant $G = 6.68\times10^{-11}$ N·m$^2$ /kg$^2$

Mass of Sun $= 2.0\times10^{30}$ kg

Mass of Earth $= 6.0\times10^{24}$ kg

Radius of Earth $= 6.4\times10^{6}$ m

Radius of Sun $= 7.0\times10^{8}$ m

Electron mass $m_e = 9.1\times10^{-31}$ kg

Electron charge $e = 1.6\times10^{-19}$ C

Electric constant (permittivity) $\epsilon_0 = 8.85\times10^{-12}$ C$^2$ /N·m$^2$

Magnetic constant (permeability) $\mu_0 = 4\pi\times10^{-7}$ T·m/A

Plank's constant $h = 6.63\times10^{-34}$ J·s

1 eV $= 1.6\times10^{-19}$ J

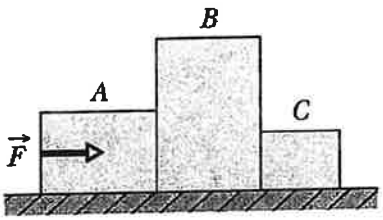
Boltzmann constant $k_b = 1.380\times10^{-23}$ J·K$^{-1}$

第一部分：填充及簡答題（80 分）

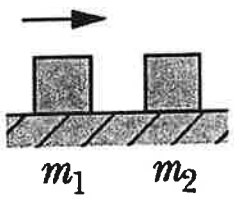
共 16 題，每題 5 分，請於答案卷上**依序作答**並**標明題號**（無需詳列計算過程）。

1. A particle goes through uniform circular motion. At one instant, it is at the $xy$ coordinates (−2.0 m, 3.0 m), has velocity $\boldsymbol{v} = -4.0\,\boldsymbol{j}$ m/s, and has acceleration $\boldsymbol{a} = +2.0\,\boldsymbol{i}$ m/s$^2$. What is the $x$ coordinate (m) of the center of the circle? _____.

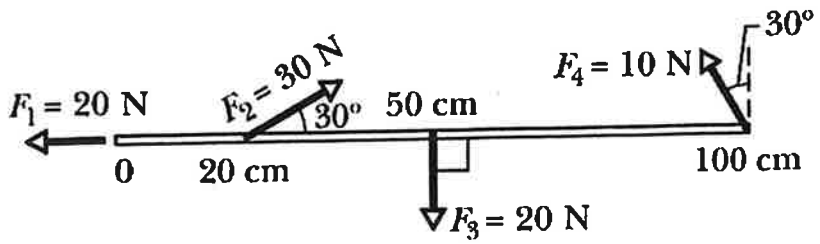
2. The figure shows a horizontal force of magnitude $F = 54$ N applied to one of three blocks with these masses: $m_A = 2.0$ kg, $m_B = 5.0$ kg, and $m_C = 2.0$ kg. The blocks move rightward across a frictionless floor. What is the magnitude (N) of the force on block $B$ due to block $A$? _____.




3. The figure shows block 1 (with velocity 10 m/s) sliding into a stationary block 2 (mass $m_2 = 6.0$ kg), which ends up with a velocity of $v_{2f} = 5.0$ m/s. The collision is elastic. What is the mass (kg) of block 1? _____.




4. The figure is an overhead view of a 4.0 kg meter stick that can rotate around a pivot located at the mark of "20 cm". Four horizontal forces act on the stick (the forces maintain their orientations relative to the stick as the stick rotates). The stick starts from rest at time $t = 0$ s. What is its angular speed (rad/s) at time $t = 6.0$ s? Don't round-off early. For a uniform stick rotating around its center of mass, the rotational inertial is given by $ML^2/12$, where $M$ is the mass and $L$ is the length. _____.



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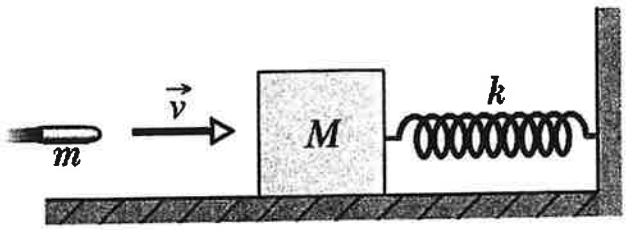
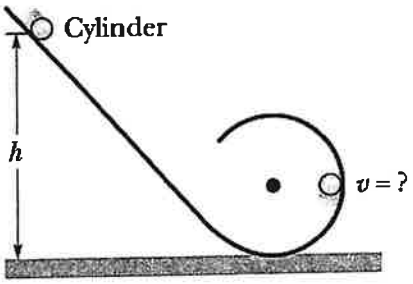
5. As shown in the figure, a block of mass $M = 5.40$ kg, at rest on a horizontal frictionless table, is attached to a rigid wall by a spring with spring constant $k = 6000$ N/m. A bullet of mass $m = 9.50 \times 10^{-3}$ kg and speed $v$ strikes and is embedded in the block. After the bullet is embedded, the block and bullet undergo SHM with amplitude $1.50 \times 10^{-2}$ m. What was the bullet speed $v$ (m/s)? _____.




6. The figure shows a cylinder that has an initial speed of 8.00 m/s at an initial height of $h = 9.00$ m. What is the normal force (N) acting on the cylinder when it reaches mid-height (level with the center) of the circular loop, which has a radius of 5.00 m? It rolls smoothly along the track. The cylinder's mass is 6.00 kg. _____.




7. Here are three pairs of waves that we can send along a string. Rank the pairs according to the amplitude of the resultant wave that would result on the string, greatest first. _____. [Note: 請依序排列，並加註大於、小於、或等於符號(>, <, or =)]

Pair 1:

$y_1 = (4.0 \text{ mm}) \sin(6\pi x - 12\pi t + 0.7\pi)$

$y_2 = (4.0 \text{ mm}) \sin(6\pi x - 12\pi t + 0.7\pi)$

Pair 2:

$y_1 = (4.0 \text{ mm}) \sin(3\pi x - 5\pi t + 0.2\pi)$

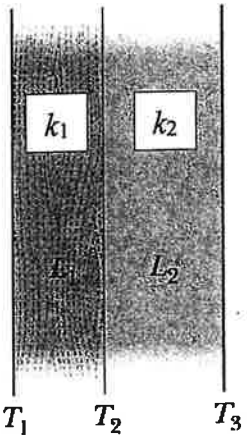
$y_2 = (4.0 \text{ mm}) \sin(3\pi x - 5\pi t + 1.2\pi)$

Pair 3:

$y_1 = (4.0 \text{ mm}) \sin(2\pi x - 4\pi t)$

$y_2 = (4.0 \text{ mm}) \sin(2\pi x - 4\pi t + 0.5\pi)$

8. The figure shows the cross section of a two-layer wall. The temperatures for the left face, interface, and right face are $T_1 = 30$ °C, $T_2 = 20$ °C, and $T_3 = -10$ °C. Layer 1 has thickness 0.20 m; layer 2 has thickness 0.60 m. What is the thermal conductivity $k$ of layer 2 in terms of that of layer 1? That is, what goes in the blank here: $k_2 =$ ____ $k_1$ ?




9. A Carnot engine with a high-temperature reservoir is at 380 K operates at an efficiency of 25.0%. By how much (K) should the temperature of the low-temperature reservoir be changed to increase the efficiency to 35.0%? _____.

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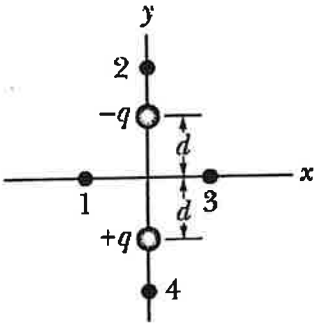
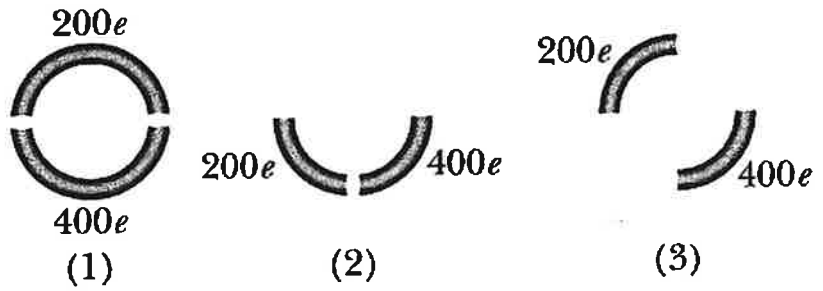
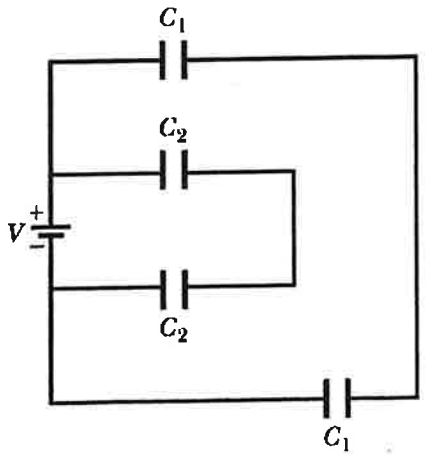
10. Two identical point charges are placed symmetrically at the same distance $d$ from the origin, as shown in the figure. Four labelled points (1, 2, 3, 4) are indicated on the diagram. At which of these labelled points does the net electric field point in the + y-direction? _____.




11. The figure shows three arrangements of charged arcs forming a circle or part of a circle. The radii are identical. Rank the arrangements according to the net electric potential at the center of curvature, most positive first, most negative last. _____. [Note: 請依序排列，並加註大於、小於、或等於符號(>, <, or =)]




12. The figure shows a 6.00 V battery and four capacitors: $C_1 = 10.0\ \mu F$ and $C_2 = 20.0\ \mu F$. What is the potential (V) across $C_1$?




13. The figure shows a wire that changes in width. However, we don't know if the wire narrows as in the first drawing or widens as in the second drawing. The drift speed in region 1 at the left is $8.00 \times 10^{-9}$ m/s. The resistivity is $1.69 \times 10^{-8}$ ohm-m. The density of conduction electrons is $8.49 \times 10^{28}$ m$^{-3}$. In both sections, the current is uniformly distributed over the cross section. In region 2 on the right, in length $L$ =

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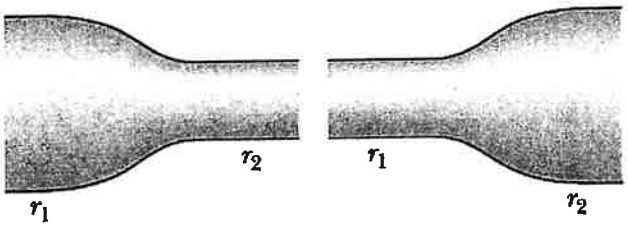
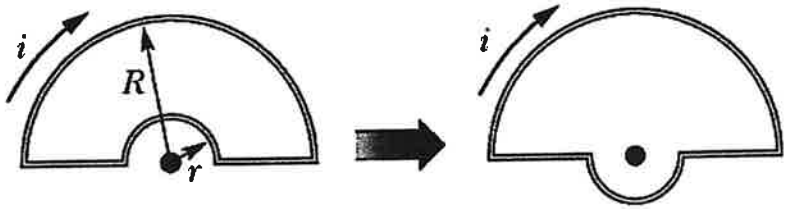
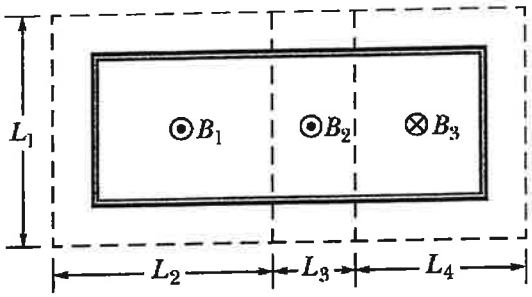
1.00 cm, the potential change $\Delta V = 1.80 \times 10^{-7}$ V. What is the ratio of radii $r_1/r_2$? _____.



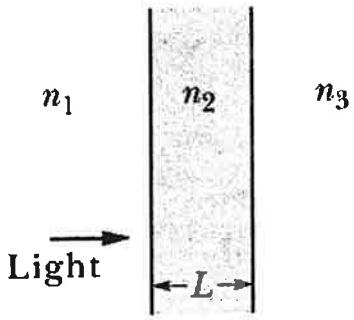

14. The first figure shows a closed loop with current $i$. The loop consists of a half-circle of radius $r$ and a half circle of radius $R = 2r$. The second figure shows the same half-circles but the small one has been flipped over. The net magnetic field at the common center of the circular sections is $B_1$ for the first figure and $B_2$ for the second figure. What is the magnitude of the ratio $B_2 / B_1$ ? _____.




15. The figure shows a rectangular wire loop lying in three magnetic fields given by these functions (in teslas and seconds): $B_1 = 3.00t$, $B_2 = 50.0$, $B_3 = 4.00t^2 + 5.00$. The dimensions are $L_1 = 2.00$ m, $L_2 = 3.00$ m, $L_3 = 1.00$ m, and $L_4 = 2.00$ m. The directions of the fields are indicated. The resistance is 5.50 Ω. What is the current (A) in the circuit at time $t = 0.500$ s? _____.




16. The figure shows a thin film (in the middle) with different materials on either side: $n_1 = 1.40$, $n_2 = 1.50$, and $n_3 = 1.60$. We send in a ray of light that is perpendicular to the two parallel surfaces. In air, that light has a wavelength of 800 nm. For some values of thickness $L$, the reflections to the left undergo fully destructive interference. What is the second smallest value of $L$ that gives that result? Answer in nanometers. _____.




 背面有題，請繼續作答。

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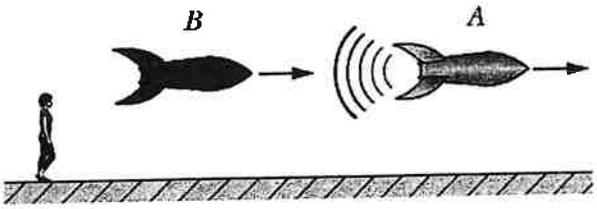
第二部分：計算題（20 分）

共 2 題，每題 10 分，請於答案卷上依序作答並標明題號（中英文作答均可，需詳列計算過程）。

1. Two spaceships travel in a straight line directly away from Earth. The leading ship **A** emits a light signal that its crew measure to have wavelength 300 nm. The pursuing ship **B**, which is behind A and moving in the same direction, receives that signal at a wavelength of 600 nm (see figure). Ship B's speed relative to Earth is 0.200 $c$, where $c$ is the speed of light.




(a) Using the Doppler shift between the two spaceships, determine the speed $v_{AB}$ of ship A relative to ship B (express your answer as a fraction of $c$). (5 points)

(b) Calculate the wavelength $\lambda_E$ that an observer on Earth would detect for the same signal (in nanometers). (5 points)

2. A star located 6.00 ly from Earth undergoes a super-nova explosion. At that distance the star behaves as an isotropic point source of light. A ground-based telescope with a circular objective of radius 1.20 m registers photons from the event at a rate of $4.50 \times 10^{20}$ photons/s. The combined optical–detector efficiency of the instrument is 80.0 %. Assume, as a rough approximation, that all the emitted light has the single visible wavelength 500 nm and that the Sun's total luminosity is $3.90 \times 10^{26}$ W.

(a) Using the measured photon rate, calculate the radiant power that reaches the face of the telescope objective. (5 points)

(b) Treating the super-nova as an isotropic source, deduce its total emission power and express your result as a multiple of the Sun's luminosity. (5 points)