臺灣綜合大學系統115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 3 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

Planck'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 moves along the x-axis. From $t = 0$ to $t = T$, its velocity is given by $v(t) = at^2$, where a is a positive constant. After $t = T$, the particle moves with a constant velocity equal to its velocity at $t = T$. The average velocity of the particle during the entire time interval from $t = 0$ to $t = 2T$ is _____.

2. A car enters an unbanked circular turn of radius 100 m at a speed of 30 m/s. The coefficient of static friction between the tires and the road is 0.40. The car will _____. (crash into the inner wall, crash into the outer wall, or stay on the track?)

3. A block of mass m slides from the highest point of a curved track to the ground. The vertical height of the highest point is h and the total length of the track is s. During the motion, the kinetic friction force f_k always acts opposite to the direction of motion, and the coefficient of kinetic friction between the block and the track is μ_k. When the block slides from the highest point to the ground, how much work is done by the normal force from the track? _____

4. A particle of mass m moves along the x-axis. Its potential energy is given by $U(x) = ax^2 - bx$, where a and b are positive constants. What is the position x at which the acceleration of the particle is zero? _____

5. Two identical carts, each of mass m, are on a frictionless horizontal track. Cart A moves with initial speed v_0 in the +x direction, while cart B is initially at rest. The carts collide, and an explosion occurs during the collision. After the explosion, the total kinetic energy of the two-cart system becomes five times its initial kinetic energy. The final velocities v_B of the cart B is_____. (Express the answer in terms of v_0)

6. A uniform rigid rod of mass M and length L is pivoted at one end and can rotate freely in a vertical plane. The rod is released from rest when it is horizontal. What is the angular speed ω of the rod when it reaches the vertical downward position? _____

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7. The same ideal gas expands from the same initial state in three ways:
a. isobaric expansion; *b*. isothermal expansion; *c*. adiabatic expansion
In each process, the gas does the same amount of work. Rank final volume for these three processes from smallest to largest (Express you answer by *a*, *b*, *c*). _____

8. A metal rod connects two large thermal reservoirs. The hot reservoir has temperature T_H, and the cold reservoir has temperature T_C, where $T_H > T_C$. A quantity of heat Q is conducted through the rod from the hot reservoir to the cold reservoir. The temperatures of the reservoirs remain constant. Find the total change of entropy of the whole system. _____

9. A circular insulating disk of radius R lies in the xy-plane. The surface charge density is nonuniform and varies with the radial distance ρ from the center according to $\sigma = C\rho$, where C is a positive constant. Taking the electric potential to be zero at infinity, the electric potential at the center of the disk is V = _____.

10. A circular coil with N turns and radius r is placed in a uniform magnetic field perpendicular to the plane of the coil. The magnetic field changes at a constant rate with time. A second circular coil is placed in the same changing magnetic field. The second coil has $2N$ turns and radius $r/2$. The ratio of the induced *emf* in the second coil to that in the first coil is $\varepsilon_2/\varepsilon_1$ = _____.

11. A capacitor discharges through a resistor R. In the original circuit, the charge on the capacitor drops from Q_0 to $Q_0/4$ after a time t_1. The resistor is then replaced by $2R$, while the same capacitor is used. In the new circuit, the time required for the stored energy to drop from its initial value U_0 to $U_0/4$ is _____.

12. A resistor R, an inductor L, and a capacitor C are connected in series to an AC source with fixed rms voltage. The resonance angular frequency is $\omega_0 = 1/\sqrt{LC}$. Let ω_1 and ω_2 be the two angular frequencies at which the average power is one-half of its maximum value. The bandwidth of the series *RLC* circuit is $\Delta\omega = \omega_2 - \omega_1$ =_____.

13. In a Young's double-slit experiment performed in air, the 6th bright fringe is observed at a distance y from the central maximum. Without changing the slit separation or the screen distance, the entire apparatus is then placed in a liquid with refractive index $n = 4/3$. The frequency of the light source remains unchanged. In the liquid, the same position y corresponds to the _____-th bright fringe.

14. In the Earth frame, two lightning strikes A and B occur simultaneously. Strike B is 600 m in front of strike A along the +x direction. A spaceship moves in the +x direction at 0.60c relative to Earth, with $\gamma = 1.25$. Observers on the spaceship find that strike B occurs before strike A. The time difference between the two strikes is _____ μs.

15. An electron is in a one-dimensional infinite potential well of width L. The energy levels are proportional to $E_n \propto n^2/L^2$. Initially, the electron is in the $n = 3$ energy level. If the width of the well is doubled to $2L$, what quantum number n' in the new well has the same energy as the original $n = 3$ level? n' = _____.

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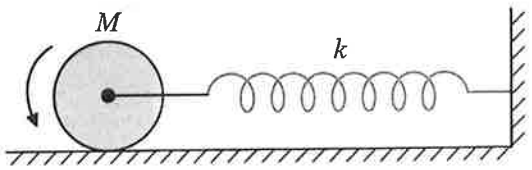
16. A metal has threshold wavelength λ_0 for the photoelectric effect, corresponding to work function ϕ. The metal is illuminated by light with wavelength $\lambda_0/3$. The maximum kinetic energy of the emitted photoelectrons is K_{max} =_____.

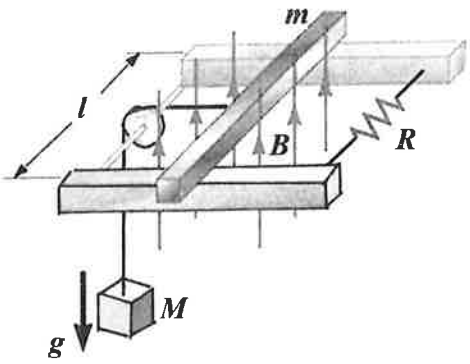
第二部分：計算題（20 分）

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. A solid disk of mass M and radius R is attached to a horizontal spring with force constant k. The disk rolls without slipping on a horizontal surface. The moment of inertia of the disk about axis through its center is $I = 0.5\,MR^2$. At $t = 0$, the disk is released from rest when the spring is stretched by x_0.
   (a) Find the angular frequency ω of the oscillation. (5 points)
   (b) Find the translational kinetic energy as a function of time, $K_{trans}(t)$, of the disk. (5 points)



2. A conducting bar of mass m slides without friction on two parallel conducting rails separated by a distance l. The rails are connected at one end by a resistor R. A uniform magnetic field $\boldsymbol{B}$ is perpendicular to the plane of the rail circuit. The bar is attached to a massless string that passes over a light, frictionless pulley. The other end of the string is attached to a hanging object of mass M. The only significant electrical resistance in the circuit is R. At $t = 0$, the system is released from rest. Take the positive direction as the direction in which the bar is pulled by the string, and assume that the hanging mass moves downward as the bar moves.



   (a) If the bar moves with speed v, derive the magnetic retarding force acting on the bar. (5 points)
   (b) Derive the horizontal speed v(t) of the bar as a function of time. (5 points)