Part one, single choice: (40%, 每題5%) 不倒扣

1. A skier of mass m starts from rest at the top (where $\theta = 0$) of a solid sphere of radius R and slides down its frictionless surface. At what angle θ will the skier leave the sphere?

(a) $\theta = \cos^{-1}\frac{1}{3}$, (b) $\theta = \cos^{-1}\frac{1}{4}$, (c) $\theta = \cos^{-1}\frac{1}{2}$, (d) $\theta = \cos^{-1}\frac{2}{3}$, (e) $\theta = \cos^{-1}\frac{\sqrt{2}}{2}$.

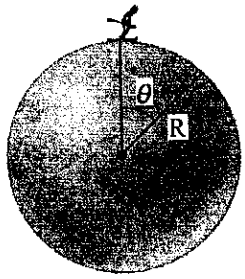

Figure 1

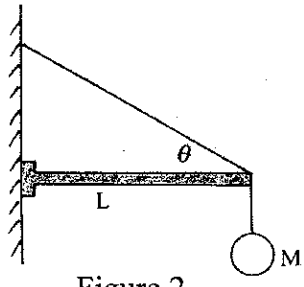

Figure 2

2. A sphere of mass M is supported by a string that passes over a light horizontal rod of length L (Figure 2). Given that the angle is θ and that the fundamental frequency of standing waves in the section of the string above the horizontal rod is f. The mass of the string above the rod is

(a) $\sqrt{\frac{Mg}{L\tan\theta}}$, (b) $\frac{Mg}{4Lf^2\tan\theta}$, (c) $\frac{2Mg}{Lf^2\tan\theta}$, (d) $\frac{2Mg}{Lf^2\cos\theta}$, (e) $\frac{Mg}{4Lf^2\cos\theta}$.

3. A thin rod of mass M and length l is suspended vertically from a frictionless pivot at its upper end. A mass m of putty traveling horizontally with a speed v strikes the rod at its center of mass (CM) and sticks there. How high h does the center of mass of the rod swing? (Note: The moment of inertia of a long uniform rod about an axis perpendicular to the rod and passing through its CM is $\frac{1}{12}Ml^2$)

(a) $h = \frac{3m^2v^2}{2g(3m+4M)(m+M)}$, (b) $h = \frac{3m^2v^2}{2g(3m+M)(m+M)}$, (c) $h = \frac{3m^2v^2}{4g(3m+M)(m+M)}$,

(d) $h = \frac{3m^2v^2}{g(3m+4M)(m+M)}$, (e) $h = \frac{6m^2v^2}{g(3m+M)(m+M)}$.

4. A large block A executes horizontal simple harmonic motion as it slides across a frictionless surface with a frequency f. Block B rests on it, as shown in Figure 3, and the coefficient of static friction between the two is μ_s. What maximum amplitude of oscillation can the system have if block B is not to slip?

(a) $\frac{\mu_s g}{\pi^2 f^2}$, (b) $\frac{\mu_s g}{2\pi^2 f^2}$, (c) $\frac{\mu_s g}{4\pi^2 f^2}$, (d) $\frac{\mu_s g}{8\pi^2 f^2}$, (e) $\frac{2\mu_s g}{\pi^2 f^2}$.

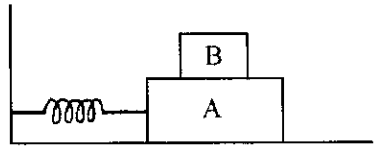

Figure 3

5. The coordinates of the eight corners of an orthorhombic conductor are at $x = 0, L$, $y = 0, w$, and $z = 0, t$. The density and charge of the charge carriers are n and q, respectively. When current I is applied along x axis and magnetic field B is applied parallel to z axis, what is the induced voltage across its width?

   (A) $nqLw/IB$, (B) $IBwt/nqL$, (C) IB/nqt, (D) $nqBt/wL$, (E) IBL/qwt.

6. A capacitor is consisted of two concentric spherical shells of radii a and b. What is the capacitance of the capacitor?

   (A) $4\pi\varepsilon_0 ab/(b-a)$, (B) $(a-b)/(4\pi\varepsilon_0 ab)$, (C) $ab/4\pi\varepsilon_0(b-a)$, (D) $4\pi\varepsilon_0(a-b)/ab$, (E) $4\pi ab/\varepsilon_0$.

7. Molybdenum has a work function of 4.20 eV. What is the maximum kinetic energy of the photoelectrons if the incident light has a wavelength of 200 nm?

   (A) 26 eV, (B) 8.4 eV, (C) 2.0 eV, (D) 1.0 eV, (E) 0.1 eV.

8. To analyze the equally spaced three-slit interference pattern, the phasor diagram can be used. The ratio of the intensity of the primary maximum and the secondary maximum is

   (A) 2, (B) 3, (C) 5, (D) 8, (E) 9.

Part two, problems: (60%, 每題 15%)

9. A bowling ball of mass M and radius R is thrown horizontally along a bowling lane so that initially ($t = 0$) it *slides* with a linear speed v_0 but *does not rotate*. The coefficient of kinetic friction between the ball and the floor is μ_k. As the ball slides, the frictional force both reduces its linear speed and increases its angular speed ω, until eventually the ball *rolls without slipping*.

   (a) **Please** draw the free body diagram of the bowling ball when it is sliding. (3%)
   (b) **How long** does it take to begin rolling without slipping? (4%)
   (c) **Find** the linear speed v_{CM} (C. M. = center of mass) of the bowling ball when it begins to roll without slipping. (4%)
   (d) **What** are the angular momentum and the total kinetic energy of the ball when the pure rolling occurs? (4%)

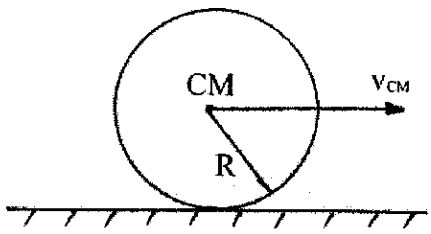

Figure 4

10. A *n*-mole sample of an ideal gas goes through the process shown in Figure 5. From A to B, the process is a *rapid*, adiabatic process; from B to C, it is isobaric, with Q_{BC} J of energy flowing into the system by heat. From C to D, the process is isothermal (at T_{CD} K); from D to A, it is isobaric, with Q_{DA} J of energy flowing out of the system by heat.

Calculate the change of internal energy, work done, the heat flow, and the change of entropy for each process, if necessary. And **fill the blanks (a)-(e) in table 1**. (3%/each blank)

Table 1

Thermodynamic processes	W (J)	Q (J)	ΔE_{int} (J)	ΔS (J/K)
B→C (isobaric)	(a)	Q_{BC}	--	--
C→D (isothermal)	(b)	--	--	--
D→A (isobaric)	--	$-Q_{DA}$	(c)	--
A→B (rapidly adiabatic)	--	--	(d)	(e)

Notes: ΔE_{int} = change of the internal energy during this process
Q = heat flow during this process, $Q > 0$ means heat flow into the system; Q_{BC} *and* $Q_{DA} > 0$
W = work done during this process, $W > 0$ means work done *on the environment by the system*
ΔS = change of the entropy during this process

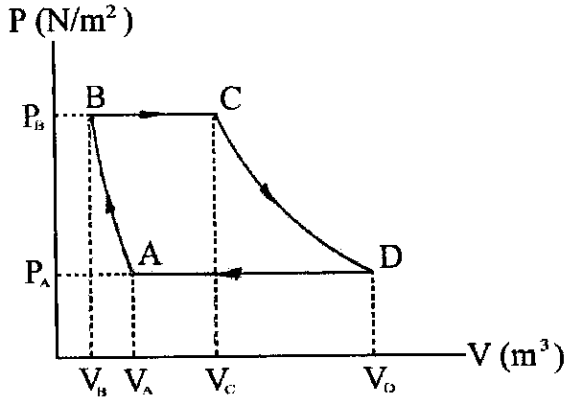

Figure 5

11. Two rods of lengths L_1 and L_2 have uniformly distributed charges of q_1 and q_2, respectively. Find the electric force between two rods if two rods locate along x axis and have a distance d between the two nearest ends. (15%)

12. A long solenoid of radius R has n turns of wire per unit length and carries a time varying current that varies as $I(t) = I_o \cos(\omega t)$, where ω is the angular frequency of the alternating current source. What is the magnitude of the induced electric field inside the solenoid, a distance r from the axis? (15%)