題號： 58　　　　國立臺灣大學 111 學年度碩士班招生考試試題

科目： 普通物理學

節次： 6

5 points for each question (每題 5 分)　　※　注意：請於試卷內之「選擇題作答區」依序作答。

Question 1-2

A wheel with rotational inertia I is mounted on a fixed, frictionless axle. The angular speed ω of the wheel is increased from zero to ω_1 in a time interval T.

1. What is the average net torque on the wheel during this time interval? (A) $\frac{\omega_1}{T}$ (B) $\frac{I\omega_1^2}{T}$ (C) $\frac{I\omega_1}{T^2}$ (D) $\frac{I\omega_1}{T}$ (E) $\frac{I\omega_1}{2T}$

2. What is the average power input to the wheel during this time interval? (A) $\frac{I\omega_1}{2T}$ (B) $\frac{I\omega_1^2}{2T}$ (C) $\frac{I\omega_1^2}{2T^2}$ (D) $\frac{I^2\omega_1}{2T^2}$ (E) $\frac{I^2\omega_1}{T^2}$

Question 3-4

An Otto refrigerator cycle is shown in **figure 1**, where processes B to A and D to C are adiabatic and processes C to B and A to D are isochoric (i.e., isovolumetric). The refrigerator is working with an ideal gas with $C_P/C_V = 5/3$. If $V_A = 2V_B$ and $P_C = 2P_B$,

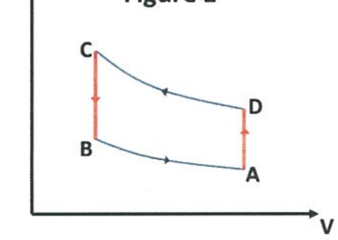

Figure 1

3. What is the ratio of $\frac{T_A}{T_B}$? (A) 2 (B) $2^{-\frac{1}{3}}$ (C) $2^{-\frac{2}{3}}$ (D) $2^{\frac{1}{3}}$ (E) $2^{\frac{2}{3}}$

4. What is the entropy change along the A to D process?

   (A) $nC_V\ln 2$ (B) $nC_V\ln 3$ (C) $nC_V\ln 2^{-\frac{2}{3}}$ (D) $nC_V\ln 3^{\frac{1}{3}}$ (E) 0

Question 5-6

An ideal gas with $C_P/C_V = 5/3$ is the working substance in an engine that operates on the cycle shown in **figure 2**. If $P_2 = 3P_1$ and $T_2 = 3T_1$,

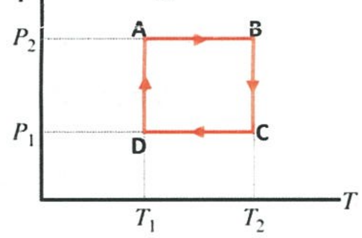

Figure 2

5. What is the total heat transferred during the full cycle?

   (A) $5nRT_1$ (B) $2nRT_1\ln 3$ (C) $2nRT_2\ln 2$ (D) $5nRT_1\ln 2$ (E) $6nRT_2\ln 3$

6. What is the efficiency of this engine?

   (A) $\frac{\ln 2}{2+3\ln 2}$ (B) $\frac{\ln 3}{3+3\ln 2}$ (C) $\frac{2\ln 2}{4+3\ln 2}$ (D) $\frac{2\ln 3}{5+3\ln 3}$ (E) $\frac{3\ln 2}{5+3\ln 3}$

Question 7-8

A round cylinder of mass *M*, radius *R*, and moment of inertia $I = 2/3\ MR^2$, is released from rest at the top of an incline (*A*) tilted at θ degrees relative to the horizontal. The cylinder rolls down the incline to the bottom without slipping, as shown in **figure 3**. The gravitational acceleration is *g*.

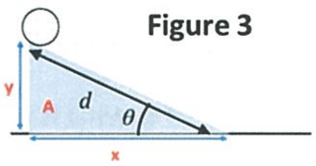

Figure 3

7. What is the acceleration of the cylinder as it rolls down the incline?

   (A) $\frac{3}{5}g\sin\theta$ (B) $g\sin\theta$ (C) $\frac{2}{5}g\cos\theta$ (D) $\frac{2}{3}g\tan\theta$ (E) $g\tan\theta$

8. What is the minimum coefficient of friction necessary for the cylinder to roll without slipping down the ramp?

   (A) $\frac{3}{8}\sin\theta$ (B) $\frac{2}{5}\cos\theta$ (C) $\frac{2}{5}$ (D) $\frac{2}{5}\tan\theta$ (E) $\frac{2}{5}\sin\theta$

Question 9-10

Two masses, m_1 and m_2 are connected together by a spring with a spring constant of k, as shown in figure 4.

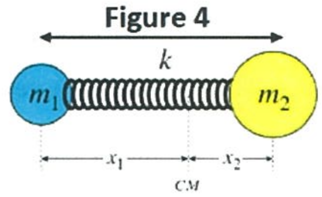

Figure 4

9. What is the oscillating amplitude of ratio $(\frac{\Delta x_2}{\Delta x_1})$ of m_2 (Δx_2) over m_1 (Δx_1)?

   (A) $\frac{m_2}{m_1}$ (B) $\frac{m_2+m_1}{m_1}$ (C) $\frac{m_1}{m_2}$ (D) $\frac{m_2+m_1}{m_1 m_2}$ (E) $\frac{1}{m_1}$

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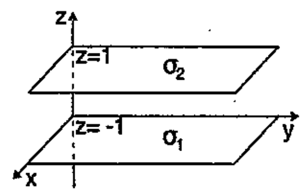
10. What is the natural angular frequency of the system?

(a) $\sqrt{\frac{k(m_2+m_1)}{m_2 m_1}}$ (B) $\sqrt{\frac{k}{m_2+m_1}}$ (C) $\sqrt{\frac{k}{m_2}}$ (D) $\sqrt{\frac{k}{m_1}}$ (E) $\sqrt{\frac{k}{m_2 m_1}}$

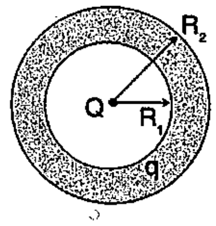
11. Two infinite planes of constant surface charge densities σ_1 and σ_2 are located at $z=-1$ and $z=1$, respectively, both parallel to the x-y plane. What is the electric field in the range $1>z>-1$?



(A) $\boldsymbol{E}=\hat{z}\frac{\sigma_1-\sigma_2}{2\epsilon_0}$ (B) $\boldsymbol{E}=\hat{z}\frac{\sigma_2-\sigma_1}{2\epsilon_0}$ (C) $\boldsymbol{E}=\hat{z}\frac{\sigma_1-\sigma_2}{\epsilon_0}$ (D) $\boldsymbol{E}=\hat{z}\frac{\sigma_2-\sigma_1}{\epsilon_0}$ (E) $\boldsymbol{E}=0$.

Question 12-13

A very long cylindrical conducting shell of total charge q, length h, inner radius R_1 and outer radius R_2 ($h \gg R_2 > R_1$) is concentric to a conducting wire of total charge Q at the center. (The figure on the right shows the cross-sectional view.) Choose $V(R_2)=0$ as a convention. Answer the following two questions.



12. Which statement below is correct? (In the following, log denotes natural log.)

(A) $E(r)=\frac{q}{4\pi\epsilon_0 r^2}\hat{r}, V(r)=\frac{q}{4\pi\epsilon_0 r}$ for $r>R_2$. (B) $E(r)=\frac{Q+q}{4\pi\epsilon_0 r^2}\hat{r}, V(r)=\frac{Q+q}{4\pi\epsilon_0 r}$ for $r>R_2$.

(C) $E(r)=\frac{Q+q}{2\pi\epsilon_0 hr}\hat{r}, V(r)=\frac{Q+q}{2\pi\epsilon_0 h}log\left(\frac{R_2}{r}\right)$ for $r>R_2$. (D) $E(r)=\frac{Q}{2\pi\epsilon_0 hr}\hat{r},\ V(r)=\frac{Q}{2\pi\epsilon_0 h}log\left(\frac{r}{R_1}\right)$ for $R_2>r>R_1$.

(E) $E(r)=0,\ V(r)=\frac{Q}{2\pi\epsilon_0}log\left(\frac{R_2}{R_1}\right)$ for $R_2>r>R_1$.

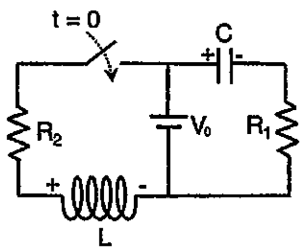
13. What is the electric potential for $R_1>r>0$?

(A) $V(r)=\frac{1}{4\pi\epsilon_0}\left[\frac{Q}{r}+\frac{Q}{R_2}-\frac{q}{R_1}\right]$. (B) $V(r)=\frac{1}{4\pi\epsilon_0}\left[\frac{Q}{r}+\frac{Q+q}{R_2}-\frac{Q}{R_1}\right]$. (C) $V(r)=\frac{Q}{2\pi\epsilon_0 h}log\left(\frac{R_1}{r}\right)$.

(D) $V(r)=\frac{Q}{2\pi\epsilon_0 h}log\left(\frac{R_1 r}{R_2^2}\right)$. (E) $V(r)=\frac{1}{2\pi\epsilon_0 h}\left[Qlog\left(\frac{R_1}{r}\right)-qlog\left(\frac{R_2}{R_1}\right)\right]$.

Question 14-15

Consider the circuit on the right. The switch remains off for $t\in(-\infty,0)$ and it is turned on at $t=0$. Answer the following two questions.



14. What is the potential difference V_C on the capacitor and the current I_L on the inductor at $t=0^+$, instantaneously after the circuit is closed?

(A) $V_C=0, I_L=0$. (B) $V_C=0, I_L=V_0/R_2$. (C) $V_C=V_0/R_1, I_L=0$. (D) $V_C=V_0, I_L=0$. (E) $V_C=V_0, I_L=V_0/R_2$.

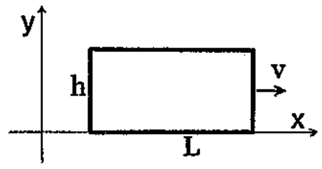
15. What happens in the limit $t\to\infty$?

(A) $V_C=0, I_L=0$. (B) $V_C=0, I_L=V_0/R_2$. (C) $V_C=V_0/R_1, I_L=0$. (D) $V_C=V_0, I_L=0$. (E) $V_C=V_0, I_L=V_0/R_2$.

16. Which statement below is correct?

(A) Two capacitors C_1, C_2 in parallel is equivalent to the capacitance of $(C_1^{-1}+C_2^{-1})^{-1}$, (B) The potential energy of a capacitor C at potential difference V equals CV^2, (C) Maxwell's equations imply charge conservation, (D) Maxwell's equations imply the Lorentz force law. (E) The (volume) energy density for a magnetic field $\boldsymbol{B}$ in vacuum is $\frac{|B|}{2\mu_0}$.

17. A background of magnetic field $\boldsymbol{B}(x,y) = \hat{z}(a+by)x$ is prepared on the x-y plane for given constants a and b. A rectangular loop (see figure) moves at a constant velocity v. The bottom of the loop coincides with the x axis, and its left side is at $x=0$ when $t=0$. What is the induced *emf* on the loop at time t? (z direction points out of plane.)



(A) $(a+bh)Lv$ clockwise. (B) $(a+bh)Lv$ counter-clockwise. (C) $(ah+bh^2/2)Lv$ clockwise. (D) $(ah+bh^2/2)Lv$ counter-clockwise. (E) 0.

18. Which statement below is correct?

(A) A point charge at constant velocity radiates due to Lorentz contraction. (B) A point charge in free fall in a gravitational field feels no back-reaction force. (C) A point charge in free fall does not radiate. (D) A radiation in an inertial frame may appear like vacuum in another inertial frame. (E) The energy radiated from an accelerating point charge per unit time is the same in every inertial frame.

19. An electromagnetic wave in vacuum has the electric field $\boldsymbol{E} = \hat{y}E_0 cos(\omega t - kx)$, where $\omega = ck$. What is the magnetic field?

(A) $\boldsymbol{B} = \hat{z}\frac{E_0}{c} sin(\omega t - kx)$. (B) $\boldsymbol{B} = \hat{x}cE_0 sin(\omega t + kz)$. (C) $\boldsymbol{B} = \hat{z}\frac{E_0}{c} cos(\omega t - kx)$. (D) $\boldsymbol{B} = \hat{x}cE_0 cos(\omega t + kz)$.

(E) $\boldsymbol{B} = \hat{y}cE_0 sin(\omega t - kx)$.

20. Which statement below is correct?

(A) In the double-slit experiment, it would be easier to see the double-slit interference pattern if the width of the slits is larger than the distance between the slits. (B) Electromagnetic plan waves have 3 independent polarizations. (C) The sky is blue because it reflects the image of the sea. (D) For a small spherical mirror of radius R, its focus is $R/2$. (E) The rainbow appears in the direction of the sun.

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