For examiners' use only

1	
2	
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6	
Total	

BBC4923 A

Joint Programme Examinations 2021/22

BBC4923 Physics D

Paper A

Time allowed 2 hours

Answer ALL questions

Complete the information below about yourself very carefully.

QM student number	
BUPT student number	
Class number	

NOT allowed: electronic dictionaries.

INSTRUCTIONS

1. **You must NOT take answer books, used or unused, from the examination room.**
2. Write only with a black or blue pen **and in English**.
3. Do all rough work in the answer book – **do not tear out any pages**.
4. If you use Supplementary Answer Books, tie them to the end of this book.
5. Write clearly and legibly.
6. **Read the instructions on the inside cover.**

Filename: 2122_BBC4923_A No answer book required

Question 1 (30 marks)

For each of following questions, write down the choice of letter in the 【 】(Single letter choice).

1) The velocity of a particle is given by $\vec{v} = -18\sin(3t)\hat{i} + 18\cos(3t)\hat{j}$ (SI), the path of the particle is?

C

(A) $x^2 + y^2 = 324$; (B) $x^2 + y^2 = 9$; (C) $x^2 + y^2 = 36$; (D) $x^2 + y^2 = 6$

【 】(3 marks)

2) A person stands at the side of the cliff with height 50m, who throw a stone with speed of 20m/s and in horizontal direction, so the stone has a projectile motion. At t= 1.5s, the magnitude of stone's tangential acceleration is? (here, g=10 m/s^2)

A

8 6 $g = 10$

(A) 6 m/s^2; (B) 10 m/s^2; (C) 8 m/s^2; (D) 13.3m/s^2

【 】(3 marks)

3) A disk with moment of inertia $\boldsymbol{I}$ rotates about a fixed axis with an initial angular velocity ω_0. Suppose the blocked torque is proportional to the rotational angular velocity $M = -k\omega$ (k is a positive constant). The time required for the angular velocity change from ω_0 to $\omega_0/2$ is ?

$\tau = -k\omega.$

C.

(A) $I/2$; (B) I/k; (C) $(I/k)\ln 2$; (D) $I/2k$

$\tau = -k\omega = I\alpha$ $\alpha = -\frac{k\omega}{I}$

【 】(3 marks)

$d\omega = \alpha dt$

$d\omega = -\frac{k\omega}{I} dt$

$\therefore \frac{1}{\omega} d\omega = -\frac{k}{I} dt$

$\ln 2 = \frac{k}{I} t$

$t = \frac{I \ln 2}{k}$

4) A horizontal circular platform can rotate without friction about the fixed perpendicular axis through its center. A child stands on it. At the beginning, the system of platform and child are at rest. Then the child starts to walk randomly on it. During the whole procedure for the system, which quantities are conserved?

C.

(A) only the momentum is conserved;

(B) only the mechanical energy is conserved;

(C) only the angular momentum about the rotational axis is conserved;

(D) momentum, mechanical energy and angular momentum about the rotational axis are all conserved.

【 】(3 marks)

5) Two sinusoidal waves travel in the same direction and have the same frequency. Their amplitudes are y_{1m} and y_{2m}. The smallest possible amplitude of the resultant wave is?

B.

(A) $y_{1m} + y_{2m}$ and occurs when they are out of phase ;

(B) $|y_{1m} - y_{2m}|$ and occurs when they are out of phase ;

(C) $y_{1m} + y_{2m}$ and occurs when they are in phase ;

(D) $|y_{1m} - y_{2m}|$ and occurs when they are in phase ;

【 】(3 marks)

6) An oscillator in simple harmonic motion moves in x-axis. The parameters for this oscillator are: at $t = 0$, $x_0 = -0.01$ m, $v_0 = 0.03$ m/s, $\omega = \sqrt{3}$ rad/s. Which of the following expression for the displacement of the oscillator is correct.

B

$V = \frac{dx}{dt} = -0.02\sqrt{3}\sin(\sqrt{3}t + \phi)$

$t=0$ $\sin\phi = -\frac{\sqrt{3}}{2}$.

(A) $x = 0.02\cos\left(\sqrt{3}t + \frac{2\pi}{3}\right)$(SI); (B) $x = 0.02\cos\left(\sqrt{3}t + \frac{4\pi}{3}\right)$(SI);

(C) $x = 0.01\cos\left(\sqrt{3}t + \frac{2\pi}{3}\right)$(SI); (D) $x = 0.01\cos\left(\sqrt{3}t + \frac{4\pi}{3}\right)$(SI).

【 】(3 marks)

7) Three equal charges are located at the corners of an equilateral triangle. If each of the charges were to be doubled, then the resulting force on each of the charges is?

D.

$F = \frac{kQ_1Q_2}{R^2}$

(A) Remains the same; (B) Doubles; (C) Triples; (D) Quadruples

【 】(3 marks)

8) Displacement current exists wherever there is?

B

(A) a magnetic field; (C) an electric field

(B) a changing electric field; (D) a changing magnetic field

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【 】(3 marks)

9) In the figure 1, a full Gaussian surface encloses two of the four positively point charges. Which of the point charges contribute to the electric field at point P on the surface?

A.

(A) all point charges;

(B) Only q_1, q_2;

(C) Only q_3, q_4;

(D) None of point charge.

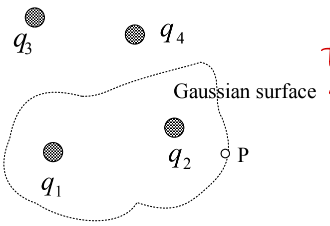

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Figure 1 【 】(3 marks)

10) A conductor consists of a circular loop of radius R and two straight, long sections. The wire lies in the plane of the paper and carries a current I. What is the vector magnetic field at the center of the loop?

B

(A) $\frac{\mu_0 I}{2\pi R}$; (B) $\frac{\mu_0 I}{2R}(1+\frac{1}{\pi})$; (C) $\frac{\mu_0 I}{4R}(1+\frac{1}{\pi})$; (D) $\frac{\mu_0 I}{4R}$

$B_1 = \frac{\mu_0 I}{2\pi R}$

$B_2 = \frac{\mu_0 I}{2R}$

$\frac{\mu_0 I}{2R}(\frac{1}{\pi}+1)$

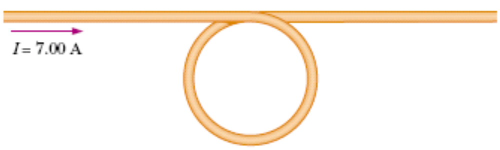

Figure 2 【 】(3 marks)

Question 2 (30 marks, each blank 3 marks)

For each of following questions, write down the answers in the blanks.

mov.

Fot.

1) The motion equation of an object with mass m=1kg is $\vec{r} = 2t\hat{i} + (2-t^3)\hat{j}$ (SI). The impulse of the resultant force acted on the object from t=1s to t=2s is $-9\hat{j}$ N·S.

$v = \frac{dr}{dt} = 2i - 3t^2 j$

$-3j$

$\rightarrow -12j$

2) An electric motor exerts a constant torque of $\tau = 10N \bullet m$ on a grindstone with the moment of inertia $I = 5.0kg \bullet m^2$. If the system starts from rest, the kinetic energy at $t = 5.0s$ is 250 J.

$\tau = I\alpha$

$\alpha = \frac{d\omega}{dt}$

$\omega = 10$

$\frac{1}{2} \cdot I \cdot \omega^2$

$\frac{1}{2} \times 5 \times 10^2$

3) Figure 3 shows a uniform thin rod with mass M and length l, the moment of inertia about the axis located at an arbitrary distance h from the center of mass is ______________.

$\frac{1}{12}ML^2 + mh^2$

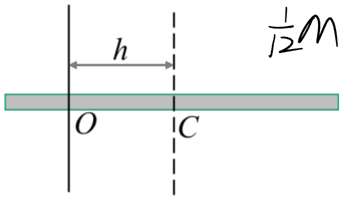

Figure 3

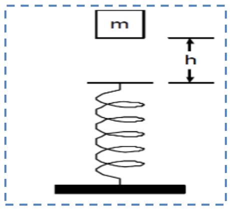

Figure 4

$mg = kx$, $x = \frac{mg}{k}$

$W = mgh + mgx - \frac{1}{2}kx^2$

$= mgh + \frac{m^2g^2}{k} - \frac{1}{2}k\frac{m^2g^2}{k^2}$

$= mgh + \frac{m^2g^2}{2k}$

4) As shown in figure 4, a block of mass m is released from rest at a distance h above a vertical massless spring with spring constant k, the maximum kinetic energy of the block is ___________.

5) A circular platform of mass m and radius R rotates friction-free about an axis through its center. A child with mass m stands on the platform a distance $R/2$ from the center. At beginning, the system of platform and child rotates at the angular velocity ω_0 about the axis. The child starts to walk to the edge of the platform. When the child arrives at the edge, the angular velocity of the system is ________________.

$W_0\left(\frac{1}{2}mR^2 + m\left(\frac{R}{2}\right)^2\right) = \left(\frac{1}{2}mR^2 + mR^2\right)W_1$

6) The phase difference between the positions and the acceleration of objects moving in simple harmonic motion is $\frac{1}{2}W_0$.

$\frac{2}{3} \times \frac{3}{4} W_0 = W_1$

7) A parallel-plate capacitor is connected to an ideal battery, which provides a fixed potential difference. Originally the energy stored in the capacitor is U_0. If the distance between the plates is doubled, then the new energy stored in the capacitor will be $\frac{1}{2}U_0$.

$C = \frac{\varepsilon S}{4\pi kd} \Rightarrow \frac{1}{2}C$

U:-

$U_0 = \frac{1}{2}CU^2$

8) An infinite plane sheet is with a uniform surface charge density σ, as shown in figure 5. The points a and b both with distance h from the surface of the sheet, the potential difference between the points a and b is 0.

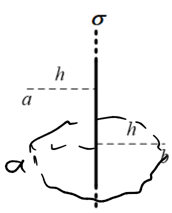

Figure 5

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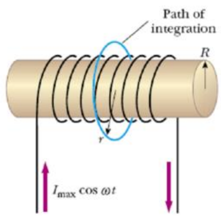


Figure 6

$\phi = B \cdot \pi R^2$

$B = \mu_0 I n$

$= n\mu_0 I_m \cos \omega t$

$E(2\pi r) = -\frac{d\phi}{dt}$

$\phi = n\mu_0 I_m \cos \omega t$

9) A long solenoid of radius R has n turns of wire per unit length and carries a time-varying current as $I = I_m \cos \omega t$, as shown in figure 6. The magnitude of the induced electric field outside the solenoid (a distance $r > R$ from its long central axis) is $\frac{n\omega\mu_0 I_m \sin\omega t R^2}{2r}$.

$\phi = n\mu_0 I_m \cos\omega t \cdot \pi R^2$

10) Write down Gauss's law for electricity on the following line.

$\phi_E = \oiint_S E \cdot dS = \frac{\sum q_i}{\varepsilon_0}$.

$E(2\pi r) = -\frac{d\phi}{dt} = \omega n\mu_0 I_m \sin\omega t R^2$

$E(2\pi r) = -\frac{d\phi}{dt}$

Question 3 (10 marks)

A uniform thin rod of length L and mass M can rotate freely in the vertical plane about a smooth horizontal axis passing through point O (shown in Fig. 7). The thin rod falls from the horizontal position without initial velocity. When the rod swings to the vertical position, the end B of the thin rod has an elastic collision with the stationary object A with mass m on the horizontal plane. After the collision, the thin rod ~~is stationary~~, and the object A slides along the horizontal plane with friction coefficient of μ. Find: $t = I\alpha$ $t = (\frac{1}{3}ML^2)\alpha = Mg\frac{L}{2}\cos\theta$. $\therefore \alpha = \frac{3g}{2L}\cos\theta$

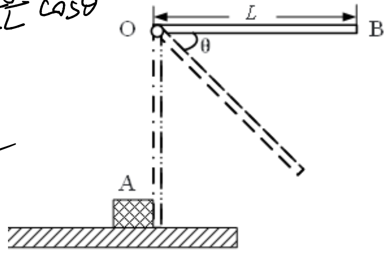


Figure 7

(1) The angular acceleration of the rod as the function of θ.

(2) The angular velocity of the thin rod just before it collides with the object A. $\alpha = \frac{d\omega}{dt} = \frac{d\omega}{d\theta}\cdot\frac{d\theta}{dt} = \frac{\omega d\omega}{d\theta} = \frac{3g\cos\theta}{2L}$

(3) The distance that the object A slides along the horizontal plane.

(3). $v = \omega\cdot\frac{L}{2} = \sqrt{\frac{3g}{L}\cdot\frac{L^2}{4}} = \sqrt{\frac{3}{4}gL}$ $\frac{1}{2}\omega^2 = \int_0^{\frac{\pi}{2}}\frac{3g\cos\theta d\theta}{2L} = \frac{3g}{2L}$. $\omega = \sqrt{\frac{3g}{L}}$.

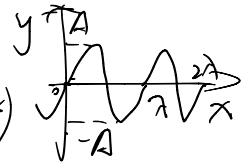
$Mv = mv_1$ $v_1 = \frac{M}{m}\sqrt{\frac{3gL}{4}}$. $\mu mgS = 0 + \frac{1}{2}mv_1^2$ $\mu gS = \frac{1}{2}\frac{M^2}{m^2}\frac{3gL}{4}$. $S = \frac{3M^2L}{8m^2\mu}$.

Question 4 (10 marks)

A harmonic wave travels in $-x$-direction with wavelength λ. If the particle at $x=\lambda/4$ oscillates with the function $y = A\cos\left(\frac{2\pi}{\lambda}ut\right)$ (SI), $A\cos[\frac{2\pi}{\lambda}ut + \frac{2\pi}{\lambda}(x - \frac{\lambda}{4})] = A\cos(\frac{2\pi}{\lambda}ut + \frac{2\pi}{\lambda}x - \frac{\pi}{2})$.

(1) Write the wave function describing the wave.

(2) Draw the waveform graph at time $t=T$ (T is the period of the wave). $t=0$. $y = A\cos[\frac{2\pi}{\lambda}x - \frac{\pi}{2})$



Question 5 (10 marks)

In Fig.8, a sphere, of radius a and charge $+q$ uniformly distributed throughout its volume, is concentric with a spherical conducting shell of inner radius b and outer radius c. This shell has a net charge of $-q$. Find expressions for the electric field, as a function of the radius r, (1) within the sphere ($r < a$), (2) between the sphere and the shell ($a < r < b$), (3) inside the shell ($b < r < c$), and (4) outside the shell ($r > c$) (5) What are the charges on the inner and outer surfaces of the shell?

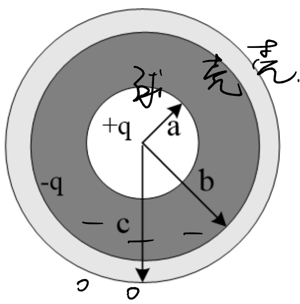


Figure 8

(1). $\frac{1}{4\pi\varepsilon_0}\frac{q}{a^2}\cdot\frac{r}{a} = \frac{qr}{4\pi\varepsilon_0 a^3}$

(2) $\frac{q}{4\pi\varepsilon_0 r^2}$ (3) 0 (4) 0.

(5). inner: $-q$
outer 0.

Question 6 (10 marks)

In Fig.9, a rectangular loop of wire with length a, width b and resistance R is placed near an infinitely long wire carrying current I, the distance between the wire and the nearest edge of the loop is c. Find:

(1) the magnitude of the magnetic flux through the loop;

(2) the induced current i_{ind} in the loop as it moves away from the long wire with speed v.

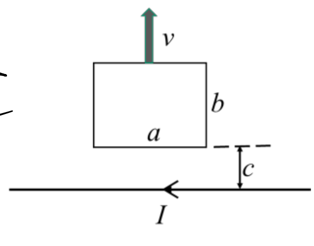


Figure 9

(1). ϕ. $d\phi = Bds = Badx = \frac{\mu_0 I}{2\pi x}adx$

$\phi = \int d\phi = \int_c^{c+b}\frac{\mu_0 Ia}{2\pi}\frac{1}{x}dx = \frac{\mu_0 Ia}{2\pi}\ln(\frac{c+b}{c})$

(2) $i_{ind} = \frac{E}{R}$

$E = BLv$. $L = a$ $B = |B_{up} - B_{down}|$ $B_{up} = \frac{\mu_0 I}{2\pi(c+b+vt)}$ $B_{down} = \frac{\mu_0 I}{2\pi(c+vt)}$

$B = \frac{\mu_0 I}{2\pi x}$ $\phi = \frac{\mu_0 Ia}{2\pi}\ln(\frac{c+b+vt}{c+vt})$ $E = \frac{d\phi}{dt}$

$x=$

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