PHY 1002 2009: Hints and Tips

Q1.

i. Thermally isolated system: $W = 0$, $Q = 0 \Rightarrow \Delta U = 0$

   Cyclic process: $\Delta U = 0 \Rightarrow Q = W \neq 0$

   Isochoric process: $\Delta = 0 \Rightarrow W = 0 \Rightarrow Q = \Delta U$

   Adiabatic process: $Q = 0 \Rightarrow \Delta U = -W$

ii. Adiabatic process: pV^{γ} =const, so Final volume = 44 atmospheres, $T_f = 896$ K

iii. Work done = $nC_v(T_2 - T_1) = 500J$

Q2.

a) Adiabatic
b) Isothermal
c) Adiabatic

$V_f = 6.79l$, $T_f = 83K$

Q3.

Temperatures: $T_1 = 240k$, $T_2 = 960k$, $T_3 = 960K$

Work: $W_{12} = 0$, $W_{23} = -552J$ (using equation for work in isothermal process), $W_{31} = -300J$ (area under curve – remember sign). Total work = -852J.

$Q = nC_v(T_2 - T_1) = 1044J = \Delta U$.

Q4. Calculation of mean free path: see notes. Expression for thermal conductivity follows from equating the rate of energy transfer across a plane to kAdQ/dx (see notes).

Mean free path = $5.8.10^{-8}$m (large c.f molecular radius).

Q5.

L = 0.24m.

Sketch should indicate that rate of energy loss from unlagged bar is proportional to excess temperature.

PHYSICS EXAMINATION PROBLEMS
SOLUTIONS AND HINTS FOR STUDENT SELF-STUDY

Module Code	**PHY1003**
Name of module	**Properties of Matter**
Date of examination	**January 2009**

1
(c) $Y = 2.5 \times 10^{10}$ Pa.
(d) Tensile Stress = 1.25×10^{9} Pa.
(e) Tensile Strain = 0.05.
(f) $\Delta l = 5 \times 10^{-3}$ m.
(g) $d = 3.87 \times 10^{-4}$ m.

2
(i)
(a) $P_A = 1.027 \times 10^{5}$ Pa.
(b) $P_B = P_A$ (same level).
(c) $P_C = 1.052 \times 10^{5}$ Pa.

(ii)
(a) $$\frac{L}{R} = \left[\frac{4\pi}{3}\frac{(\rho_w/2 - \rho_2)}{(\rho_1 - \rho_w)}\right]^{1/3}$$
(b) $L/R = 0.684$.

3
(a) $$\gamma = \frac{(m_1 + m_2)g}{2L}$$
(b) $\gamma = 0.045$ N m^{-1}.
(c) $a = 11.79$ m s^{-2}.
(d) $t = 0.26$ s.

Capillary formed between two flat plates ($\cos\theta = 1$):
$$h = \frac{2\gamma}{\rho g d}$$

4
(c) $$F(r) = \frac{2V_0}{a}\left[\left(\frac{a}{r}\right)^3 - \left(\frac{a}{r}\right)^2\right]$$
(d) *Hint: at the equilibrium interatomic separation* ($r = r_0$), $F = 0$ (*or, equivalently,* $dV/dr = 0$).

5
$r_0 = 1.131 \times 10^{-10}$ m.

PH41104 2009 HINTS 'n TIPS

1. a) $q_1 < 0$, $q_2 > 0$, $q_1 = q_2$

b) $q_1 = q_2 = 1\,nC$

c) 2.5×10^5 N/C $\hat{y}$

d) $V = 0$

$q_1 > 0$, $q_2 < 0$; consider forces

2. a) $\rho = \frac{Q}{4/3 \pi R^3}$

b) $r < R$: $\vec{E} = \frac{Qr}{4\pi R^3 \varepsilon_0} \hat{r}$ $r > R$: $\vec{E} = \frac{Q}{4/3 \pi r^2 \varepsilon_0} \hat{r}$

c) $V = \frac{Q}{4\pi \varepsilon_0 r}$

d) typo: $\alpha = \frac{3Q}{2\pi R^3}$; start with $Q = \int_0^R \rho(r) 4\pi r^2 dr$

e) $\vec{E} = \frac{3Q}{\pi R^3 \varepsilon_0} \left[\frac{r}{3} - \frac{r^2}{4R} \right] \hat{r}$

3. a) top: $-C_1 V$ bottom: $C_1 V$

b) top: $-C_2 V$ bottom: $C_2 V$

c) C_1: $\vec{E}_1 = \frac{V}{d_1} \hat{y}$ C_2: $\vec{E}_2 = \frac{V}{d_2} \hat{y}$

d) top: $-K_1 C_1 V$ bottom: $K_1 C_1 V$

e) top: $-C_2 V$ bottom: $C_2 V$

f) C_1: $\vec{E}_1 = \frac{V}{d_1} \hat{y}$ C_2: $\vec{E}_2 = \frac{V}{d_2} \hat{y}$

4. (i) a) $J = 1.4 \times 10^8$ A/m^2

b) $V = 5 \times 10^3$ V

(ii) a) $I = 0.47$ counter clockwise

b) 7.2 W

c) sum power dissipated in each resistor / battery

a) $\Delta V_R = iR$ $\Delta V_L = L \frac{di}{dt}$

b) $i = \frac{\varepsilon}{R}(1 - e^{-(R/L)t})$; start with Loop Rule for circuit

5 a) $\vec{B} = \frac{\mu_0 I_1}{2R}$ out of page

b) $I_2 = \frac{\pi D}{R} I_1$ to the left so B_2 into the page

c) current $I_2(t)$ decreasing $\Rightarrow$ induced ε acts to increase flux and current will flow counter clockwise to increase B-field

Consider integral along closed path

PHY1105

Relativity 1 and Vectors

January 2009

Hints and Tips

Q1.

(i) Involves just standard relativistic expressions for total energy and momentum. To find the kinetic energy we need simply to subtract the rest mass from the total energy.

(ii) Use the relativistic expression that relates total energy, momentum and rest energy.

Q2.

The space craft problem can be solved by considering conservation of momentum.

For the radioactive decay you will need to make use of conservation of momentum, and conservation of energy.

Q3.

(i) Involves making use of equations of motion. Note that the acceleration, provided by the force of gravity, is constant during the motion.

(ii) Part b) can be solved with the aid of the determinant form of the cross product. Part c) can be tackled by considering the vector associated with a point along the line between P and R.

Q4.

Concerning the fairground wheel, consider the net force acting on the passenger.

Q5.

(i) Consider the net force on the lift.

(ii) Make use of the conservation of momentum and the conservation of (kinetic) energy.

PHY1106

We apologise, the Hints and Tips sheet for this module is unavailable.

Please contact the Module Leader with any queries

PHYSICS EXAMINATION PROBLEMS
SOLUTIONS AND HINTS FOR STUDENT SELF-STUDY

Module Code	**PHY1116**
Name of module	**MATHEMATICS FOR PHYSICISTS**
Date of examination	**June 2009**

1. (i) $f(x) \approx 1 + \frac{x}{2} - \frac{x^2}{8} + \frac{x^3}{16} - \frac{5x^4}{128}$ (ii) hint is in question

2. Equations in matrix form: $\begin{pmatrix} 3 & 0 & -1 \\ 1 & -1 & 1 \\ 2 & 1 & 0 \end{pmatrix}\begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} = \begin{pmatrix} 1 \\ 1 \\ 2 \end{pmatrix}$; inverse matrix is

$\begin{pmatrix} -1 & -1 & -1 \\ 2 & 2 & -4 \\ 3 & -3 & -3 \end{pmatrix}$. Solutions are $\begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} = \begin{pmatrix} 2/3 \\ 2/3 \\ 1 \end{pmatrix}$

3. (i) $x = 0,\ y = -1,\ z = 1;\ r = \sqrt{2},\ \theta = \pi/4,\ \varphi = -\pi/2$

(ii)

$$\left.\frac{\partial f}{\partial x}\right|_y = y\exp(xy) - \frac{2x}{x^2+y^2},\quad \left.\frac{\partial f}{\partial y}\right|_x = x\exp(xy) - \frac{2y}{x^2+y^2},$$

$$\frac{\partial^2 f}{\partial x^2} = y^2\exp(xy) + \frac{2\left(x^2-y^2\right)}{x^2+y^2},\quad \frac{\partial^2 f}{\partial y^2} = x^2\exp(xy) + \frac{2\left(y^2-x^2\right)}{x^2+y^2}.$$

4. Use circular polars, or parameterisation: $I = \frac{1}{4}$

5. Use cylindrical polars: $M = \frac{\pi}{4}h^2a^4m_0$

6. (i) Volume $= |\mathbf{a}\cdot\mathbf{b}\times\mathbf{c}| = 42$; (ii) $-\nabla\phi = y^2\hat{\mathbf{x}} + 2xy\hat{\mathbf{y}}$

7. No hint required

8. $y = \left[3x^2(\ln x + C)\right]^{1/3}$; $C = \frac{1}{3} \Rightarrow \left[3x^2\left(\ln x + \frac{1}{3}\right)\right]^{1/3}$

9. No hint required

10. (b) As w decreases the function becomes higher and narrower, but irrespective of w, the area under the function is 1. These are the two requirements to generate a delta-function.

(d) As w tends to zero, $\frac{\sin(kw)}{kw} \to 1$ (L'Hopital's rule), hence FT of delta fn is $F(k) = \frac{1}{\sqrt{2\pi}}$

PHY1118

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