

**NATIONAL BUSINESS AND TECHNICAL EXAMINATIONS BOARD (NABTEB)**

**2007 MAY/JUNE NBC/NTC EXAMINATIONS - PHYSICS**

**MODERN QUESTIONS AND ANSWERS**

Question: 1a. State Hook's law

Answer: 1a. Hooks law states that provided the elastic limit of an elastic material is not exceeded, the extension of the materials is directly proportional to the load or force applied. ( $F = K X$ ).

$$F = KX \text{ (Provided the elastic limit is not exceeded)}$$

Where  $F$  = Applied force or load

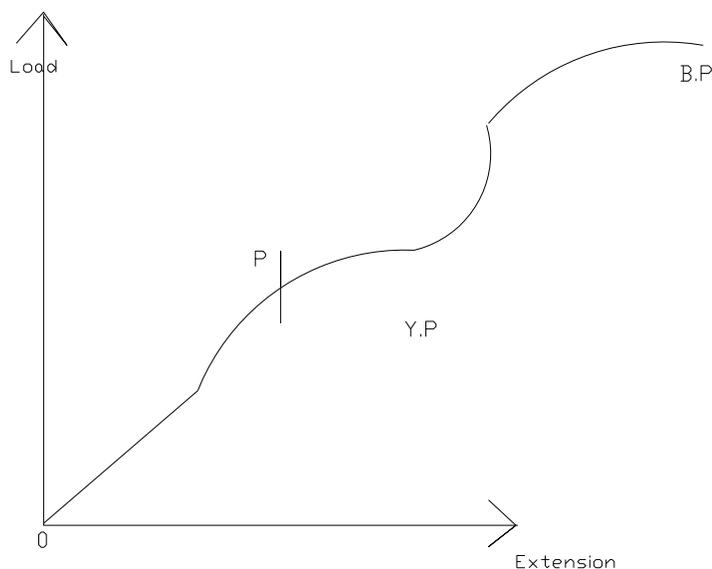
$X$  = Extension

$K$  = Proportionality constant or force constant

Question 1b. A helical spring is stretched by loading it gradually with increasing weights and the corresponding extensions recorded until the elastic limit is reached. Draw a graph of load against extension showing the following:

- i. elastic limit
- ii. yield point
- iii. breaking point

Answer 1b



- i. point P = Elastic limit
- ii. point Y.P = Yield point
- iii. Point B.P = Breaking point

Question 1c. If a spring has a stiffness of  $1000 \text{ Nm}^{-1}$ . What work will be done by extending the spring by 100 mm?

Answer: 1c. Work done =  $\frac{1}{2} FX = \frac{1}{2} KX^2$   
K = stiffness constant =  $100 \text{ Nm}^{-1}$   
X = Extension of spring =  $100 \text{ mm} = 0.1 \text{ m}$

$$\begin{aligned} \square \text{Work done} &= \frac{1}{2} \times 1000 \times (.1)^2 \text{ Joules} \\ &= \frac{1}{2} \times 1000 \times .01 \text{ J} \\ W &= 5.0 \text{ J} \end{aligned}$$

Question 2a. i. Define cubic expansivity of a gas at constant pressure  
ii. Explain why it is necessary to leave gaps between steel bars used in constructing rail way lines.

Answer: 2a. (i) Cubic expansivity of a gas at constant pressure is defined as the increase in volume of a gas per unit volume of the gas at  $0^\circ\text{C}$  per degree Celsius increase in temperature when the pressure is constant.

$$\gamma = \frac{\text{increase in volume from } 0^\circ\text{C}}{\text{Volume at } 0^\circ\text{C} \times \text{temperature change}}$$

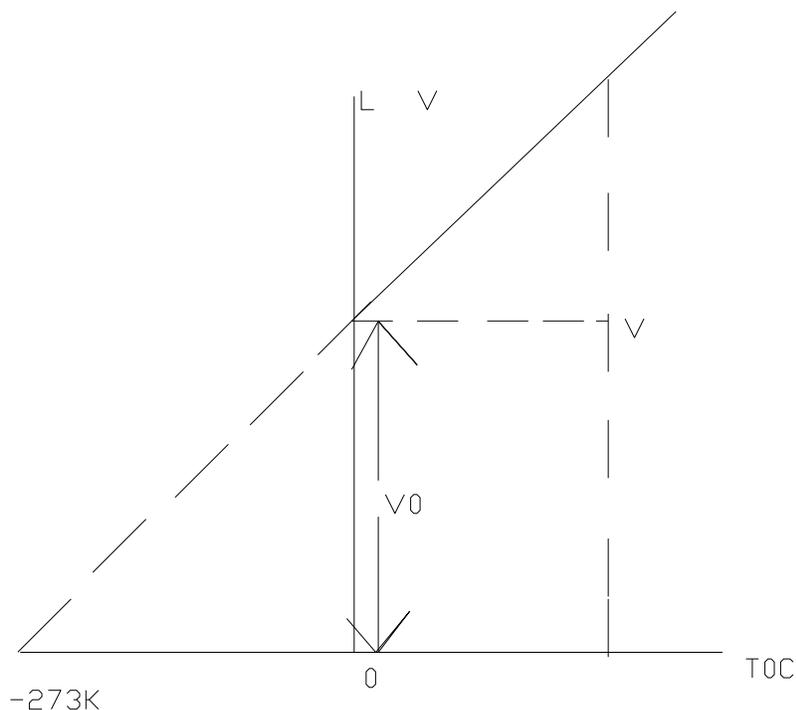
OR

$$\begin{aligned} \gamma &= \frac{V_t - V_0}{V_0 \times \Delta t} \\ V_t &= \text{Volume at } t^\circ\text{C} \\ V_0 &= \text{volume at } 0^\circ\text{C} \\ T &= \text{temperature } t^\circ\text{C} \end{aligned}$$

Answer 2a (ii) Gaps are left in between steel rails on a railway line to allow for the expansion of the bars when the temperature goes up.

Question 2b. Describe an experiment which could be in the laboratory to show that the volume of 30g of oxygen at constant pressure changes by  $\frac{1}{273}$  of its volume at  $0^\circ\text{C}$  whenever its temperature changes by  $1^\circ\text{C}$ .

Answer: 2b.



Procedure:- The 30gm of oxygen is trapped in a narrow glass capillary tube of uniform bore, by mercury pellet as in diagram

The tube is held with rubber bands onto the half meter rule, they are then placed in the water container.

A thermometer is also placed in the water. The initial temperature of the assembly is noted. The temperature of the water is gradually increased by heating. As the temperature increases the oxygen in the tube will be seen to expand under the constant atmospheric pressure at the top plus the pressure provided by the weight of the mercury pellet. The reading of the thermometer is noted for different positions of the mercury pellet. Since the tube is uniform bore, the volume of the oxygen is directly proportional to the length of the oxygen in the tube (several readings of the oxygen length and the corresponding temperatures are noted (at least 5 reading).

A graph L which is proportional to volume, is plotted against temperature  $t^{\circ}\text{C}$ . Through out, the temperature of the water is kept uniform by stirring. The graph that will be obtained is shown in Diagram. When extrapolated on the temperature axis, it cut at  $-273^{\circ}\text{C}$ .

Now cubic expansivity of gas.

$$\gamma = \frac{\text{increase in volume from } 0^{\circ}\text{C}}{\text{Volume at } 0^{\circ}\text{C} \times \text{temperature rise from } 0^{\circ}\text{C}}$$

From the graph

$$\gamma = \frac{V_t - V_0}{V_0 \times \Delta t} = \frac{1}{V_0} \left( \frac{V_t - V_0}{t} \right)$$

Slope of graph  $S = \frac{V_t - V_0}{t}$

It is also =  $\frac{V_0}{273}$

Hence  $\gamma = \frac{1}{V_0} \times \frac{V_0}{273} = \frac{1}{273}$  (per  $^{\circ}\text{C}$ )

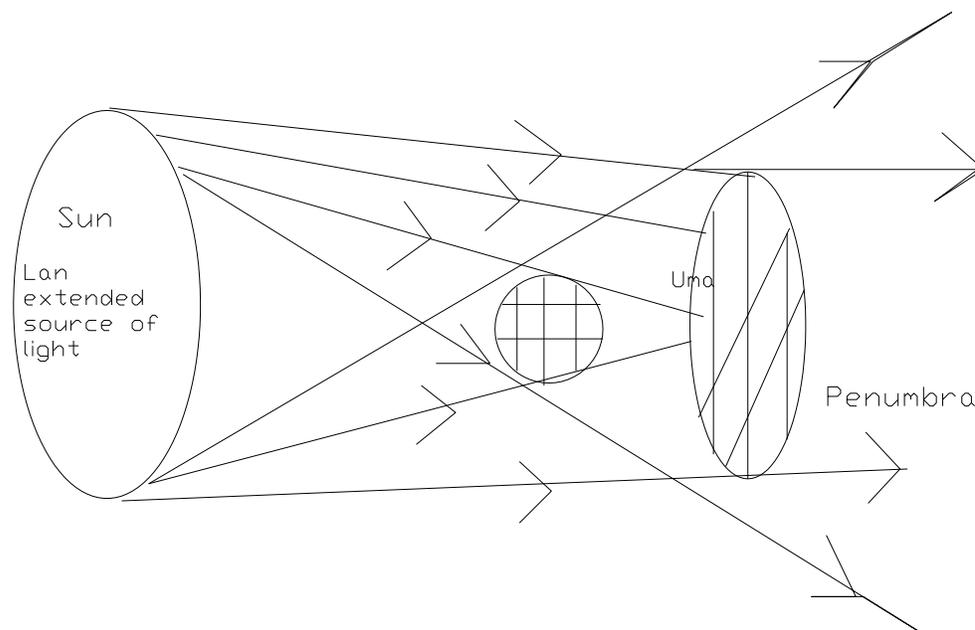
The cubic expansivity of all gases is  $= \frac{1}{273}$  (per  $^{\circ}\text{C}$ )  
 Rise in temperature =  $0.00366\text{k}^{-1}$

Question 2(C) A Bimetallic strip of brass and Aluminium is 20cm long at room temperature. What will be the difference in their lengths when the temperature is  $20^{\circ}\text{C}$  above room temperature? (linear expansivity of brass is  $0.00019\text{k}^{-1}$  and that of Aluminium is  $0.000015\text{k}^{-1}$ ).

Answer: Initial Brass Length 20cm  
 Initial Aluminium length 20cm  
 $\alpha_{\text{Brass}} = 0.00019\text{k}^{-1}$   
 $\alpha_{\text{Al}} = 0.000015\text{k}^{-1}$   
 increase in temperature =  $20^{\circ}\text{C}$   
 Brass  $L_{\text{Br}} = L_0 (1 + \alpha_{\text{Br}} \Delta T)$   
 Aluminium  $L_{\text{Al}} = L_0 (1 + \alpha_{\text{Al}} \Delta T)$   
 $(L_{\text{Br}} - L_{\text{Al}}) = L_0 (\alpha_{\text{Br}} \Delta T - \alpha_{\text{Al}} \Delta T)$   
 $= L_0 (\alpha_{\text{Br}} - \alpha_{\text{Al}}) \Delta T$   
 $= 20(0.00019 - 0.000015) 20\text{cm}$   
 $= 400(0.000175) \text{cm}$   
 Ans = 0.07cm

Question 3 (a): with the aid of a well labeled diagram describe the eclipse of the sun

Answer: 3(a). The eclipse of the sun

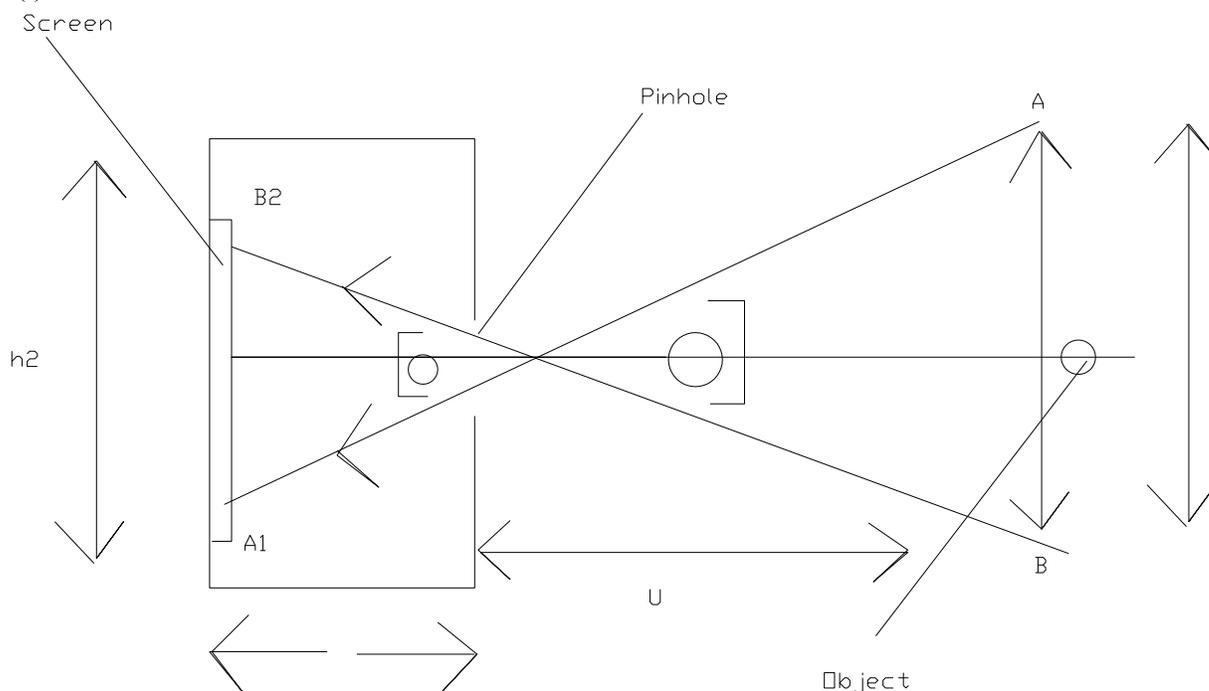


The moon is an opaque body rotating round the Earth and close to it. When it is positioned, in its orbit, between the earth and the sun and its centre is aligned with that of the sun with a portion of the surface of the Earth, we have an Eclipse of the sun. (this is shown in the diagram above). Region (AB) and (BC) are the penumbra regions (Partial shadow) while position B is the total shadow (darkness).

Question 3(b)

- i. Explain briefly the principle of operation of a pin hole camera
- ii What is the main disadvantage of the pin hole Camera?

Answer 3b (i)



The operation of the pin hole camera is based on the fact that light travels in a straight line. As shown in the diagram above, light from the A part of the object travel through the pin hole to produce an image on the photographic plate (or screen); at A<sup>1</sup>, likewise light from B will pass through the pinhole to produce image at B<sup>1</sup>.

The inside of the box is painted black to absorb stray light due to stray reflection to prevent its falling on the screen or photographic plate. The image produced is inverted B<sup>1</sup>A<sup>1</sup>, the smaller the pin hole the sharper and clearer the image but it will dimmed when the light entering the camera is limited. Whereas if the hole is big, the image will be bright but blurred.

Answer 3b (ii) Disadvantage of the pin hole camera:

1. it requires a long exposure time to develop the image on the film, allowing sufficient light to enter the boxes.
2. it can only take photograph of still objects.
3. it produces an inverted image

Question 3C. An object 50cm tall is placed in front of a pin hole camera 1m away from the camera of length 20 cm. Calculate the height of the image formed and its magnification. If the object distance is doubled, how will this affect the size and magnification of the image produced?

Answer 3c Object height = 50cm = h<sub>1</sub> = 0.5m, distance from pin hole camera = 1m = u, camera length = 20cm = V = 0.20m, image height = h<sub>2</sub>?  
Referring to the diagram, by similar triangle

$$M = \frac{V}{U} = \frac{h_2}{h_1}$$

$$\frac{h_i}{u} = \frac{h_2}{v}$$

$$\frac{0.50}{1m} = \frac{h_2}{0.20}$$

$$\begin{aligned} h_2 &= 0.5 \times 0.2m \\ &= 0.10m \end{aligned}$$

□ Image height h<sub>2</sub> = 10.00cm

$$\text{magnification } M = h_2 = \frac{\text{image height}}{h_1 \text{ object height}} = \frac{10.00\text{cm}}{50.00\text{cm}}$$

$$M = 0.20$$

If the object distance is doubled the image size will be further reduced, likewise the magnification will be further reduced.



Using the above current diagram,

- i Calculate the effective capacitance
- ii Charge on C<sub>2</sub> and C<sub>3</sub>
- iii Total energy stored in the circuit

Answer 4c.(i) C<sub>2</sub> and C<sub>3</sub> effective = (2.0 + 5.0) μf

$$\frac{1}{C_{eff}} = \frac{1}{1.5} + \frac{1}{7} \text{ where } C_{eff} \text{ is } c_1, c_2 \text{ and } c_3 \text{ effective}$$

$$C_1, C_2 \text{ and } C_3 \text{ effective } = \frac{1.5 \times 7}{1.5 + 7} = \frac{10.5}{8.5} = 1.24 \mu f$$

ii. Charge on C<sub>1</sub>, [C<sub>2</sub>, C<sub>3</sub>] = Q = CV

$$= \frac{10.5}{8.5} \times \frac{20}{1}$$

$$= 24.71 \mu C$$

$$Q_2 \text{ (on } C_2) = \frac{2}{2+5} \times 24.71 = 7.06 \mu C$$

$$Q_3 \text{ (on } C_3) = \frac{5}{2+5} \times 24.71 = 17.65 \mu C$$

iii. Total Energy stored E =  $\frac{1}{2} CV^2$  joules

$$= \frac{1}{2} C_{eff} \times 20^2$$

$$= \frac{1}{2} \times \frac{21}{17} \times 20^2 = \frac{1}{2} \times \frac{21}{17} \times 400J$$

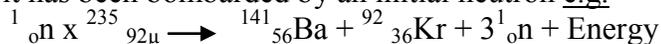
$$\frac{2}{17} \times 400J$$

$$= 247,06J$$

Question 5a. Explain the following terms and give ONE example in each case

- i. Nuclear fission
- ii. Radiation hazards
- iii. Nuclear fusion

Answer: 5a(i) Nuclear fission: This is the splitting up of the nucleus of a heavy element into two approximate equal parts with the release of a large amount of energy and some neutrons after it has been bombarded by an initial neutron e.g.

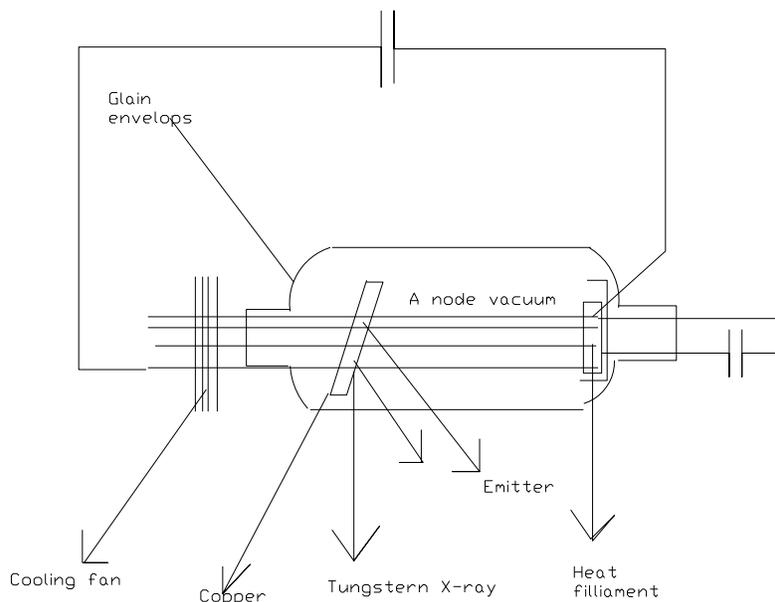


Ans 5a(ii) When the body is exposed to radioactive substances for a long time, the radiation penetrates the body and can destroy cells in the tissues and upset natural chemical reactions in the body. In some cases genetic changes can occur (Mutations) causing cancerous growth and hereditary defects.

Ans. 5a(iii). Nuclear fusion: This is a process where two or more light nuclei combine or fuse to form a heavier nucleus with the release of a large amount of energy e.g.  ${}^2_1\text{H} + {}^3_1\text{H} \longrightarrow {}^4_2\text{He} + {}^1_0n + \text{energy}$ .

Question 5(b). Explain the production of X-ray

Answer: 5(b)



X-rays are produced when electrons liberated from a hot filament (thermionic emission) are accelerated through a high potential difference and are made to impinge on a metal target like tungsten.

The diagram above shows the arrangement for the production of X-ray, the high P.D. between Anode and Cathode help to accelerate the electrons ejected from the filament to very high velocity. The X-ray tube is evacuated to prevent the electrons from colliding with air molecules thus preventing them from getting to the target. A high proportion of the kinetic energy gained is changed into heat in the target. This is transferred to the surrounding air via the cooling fins. A high melting point metal is normally used. The rest of the energy is converted to X-ray which are radiated from the tungsten metal target.

The X-ray occur from the electronic transition from the inner core shell of the target metal atom and its outer electron

- 5c. The current,  $I$  in an a.c. circuit is given by the equation,  $I = 60\sin 200\pi t$  where  $t$  is in seconds.  
Deduce the following from the equation

- i. frequency of the instantaneous current
- ii. peak value of the current
- iii. r.m.s. value of the current

Answer 5c  $I = 60\sin 200\pi t$ .  
Equation comparing with  $I = A\sin \omega t = A\sin \alpha\pi ft$   
Where  $a =$  Peak current  
 $\omega =$  angular velocity of the rotating coil producing the A.C. current  
 $t =$  time in second.

i.  $200\pi t = 2\pi ft$

$\square f = 100\text{hz.}$

ii. Peak value current occurs when  $\sin 2\pi ft = 1$

$\square \underline{1 \text{ peak} = 60 \text{ A}}$

iii. R.M.S. Value = Root mean square value

$= \frac{\text{Peak value}}{\sqrt{2}}$

$= \frac{60}{\sqrt{2}} \text{ A} = 42.43\text{A}$

$I_{\text{R.M.S.}} = 42.43\text{A}$