Cambridge International Examinations
Cambridge Pre-U Certificate

PHYSICS (PRINCIPAL) **9792/02**

Paper 2 Written Paper **For Examination from 2016**

SPECIMEN INSERT

The question in Section 2 of this paper will relate to the subject matter in this Insert. You will have received a copy of this booklet in advance of the examination.

The extracts on the following pages are taken from a variety of sources.
Cambridge International Examinations does not necessarily endorse the reasoning expressed by the original authors, some of whom may use unconventional Physics terminology and non-SI units.

You should draw on all your knowledge of Physics when answering the questions.

The syllabus is approved for use in England, Wales and Northern Ireland as a Cambridge International Level 3 Pre-U Certificate.

This document consists of **7** printed pages and **1** blank page.

Extract 1: The heating effect of an alternating current

1. An alternating current (a.c.) can be represented by the equation:

$$I = I_o \sin(2\pi ft)$$

where f is the frequency of the supply.

The heating effect depends on I^2R, and so an average of I^2 is needed, not an average of I. To find the average value, you need the average value of $\sin^2$ as time runs on.

The graph of $\sin(2\pi ft)$ and the graph of $\cos(2\pi ft)$ look the same, except for a shift of origin. Because they are the same pattern, $\sin^2(2\pi ft)$ and $\cos^2(2\pi ft)$ have the same average as time goes on. But

$$\sin^2(2\pi ft) + \cos^2(2\pi ft) = 1$$

Therefore the average values of each of them must be $\frac{1}{2}$.

Therefore the average value of the power in an a.c. transmission system must be half of the peak power.

2. The power wasted as heat in a transmission line of resistance R is

$$I_o^2 R \sin^2(2\pi ft)$$

Fig. E1.1 is a sketch graph of $\sin^2 x$ against x.

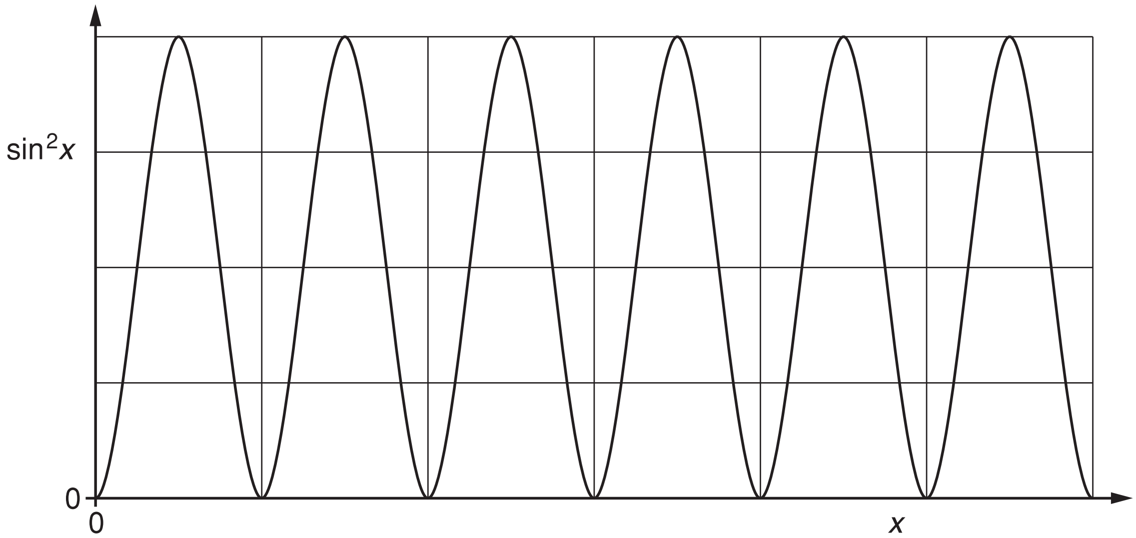

Fig. E1.1

Adapted from: http://www.practicalphysics.org/go/Guidance_107.html

Extract 2: Classic HVDC transmission

Using high voltage direct current (HVDC) to interconnect two points in a power grid, is in many cases the best economic solution. High voltages are used in transmission systems because a higher voltage implies a lower current for a given power of transmission. With a lower current, less heat is generated in the transmission lines and so less energy is wasted. Furthermore, it has excellent environmental benefits.

HVDC technology is used to transmit electricity over long distances by overhead transmission lines and over short distances when undersea cables are involved. It is also used to interconnect separate power systems, where traditional (a.c.) connections cannot be used. The Swedish company ABB pioneered HVDC technology and is the undisputed world leader in the HVDC field.

Fig. E2.1 shows the Herrenwyk station of the Baltic Cable HVDC Link.

Fig. E2.1

In an HVDC system, electric power is taken from one point in a three-phase a.c. network, converted to d.c. in a converter station, transmitted to the receiving point by an overhead line or cable and then converted back to a.c. in another converter station. It is then injected into the receiving a.c. network. Wherever possible, any voltage transformation is carried out when the current is an a.c. because transformers, which are highly efficient and cheap both to construct and operate, will not function with d.c.

Typically, an HVDC transmission system has a rated power of more than 100 MW and many are in the 1000–3000 MW range.

HVDC transmissions are used for the transmission of power over long or very long distances because it then becomes economically attractive when compared with more conventional a.c. lines.

With an HVDC system, the power flow can be controlled rapidly and accurately as to both the power level and the direction. This possibility is often used in order to improve the performance and efficiency of the connected a.c. networks.

Adapted from: http://www.abb.com/industries/us/9AAC30300393.aspx

Extract 3: Advantages of HVDC transmission

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Adapted from: http://www.dciinsulator.com/shownews.asp?id=155

Extract 4: The skin effect

Awaiting copyright clearance

Adapted from: http://www.calculatoredge.com/electronics/skin%20effect.htm

Extract 5: Disadvantages of HVDC transmission

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Adapted from: http://www.dciinsulator.com/shownews.asp?id=155

Extract 6: Transmission line capacitance

Long undersea high-voltage cables have a high electrical capacitance, because the conductors are surrounded by a relatively thin layer of insulation and a metal sheath. The geometry is that of a long co-axial capacitor. Where a.c. is used for cable transmission, this capacitance appears in parallel with the load. Additional current must flow in the cable to charge the cable capacitance, which generates additional losses in the conductors of the cable. Additionally, there is a dielectric loss component in the material of the cable insulation, which consumes power.

However, when d.c. is used, the cable capacitance is only charged when the cable is first energised or when the voltage is changed; there is no steady-state additional current required. For a long a.c. undersea cable, the entire current-carrying capacity of the conductor could be used to supply the charging current alone. This limits the length of a.c. cables. d.c. cables have no such limitation. Although some d.c. leakage current continues to flow through the dielectric, this is very small compared to the cable rating.

From: http://en.wikipedia.org/wiki/High-voltage_direct_current

Extract 7: Capacitive reactance

The ratio $\frac{V_0}{I_0}$, where I_0 is the peak current in the circuit and V_0 is the peak voltage, is known as the capacitive reactance. Capacitive reactance plays the same role for a capacitor that resistance does for a resistor.

The voltage V_t of an a.c. supply at time t is given by the expression

$$V_t = V_0 \sin\ (2\pi ft)$$

The current I_t in a circuit containing a capacitor of capacitance C is given by the expression

$$I_t = 2\pi fCV_0 \cos\ (2\pi ft)$$

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