| Surname | | Other Names | |
|---|---|---|---|
| Centre Number | | Candidate Number | |
| Candidate Signature | | | |

For Examiner's Use

General Certificate of Education
June 2008
Advanced Level Examination

**PHYSICS (SPECIFICATION A)** **PHAP**
**Practical (Units 5-9)**

Monday 19 May 2008 1.30 pm to 3.15 pm

**For this paper you must have:**
- a calculator
- a pencil and a ruler
- a data sheet insert.

Time allowed: 1 hour 45 minutes

**Instructions**
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **both** questions.
- You must answer the questions in the spaces provided. Answers written in margins or on blank pages will not be marked.
- Show all your working.
- Do all rough work in the answer book. Cross through any work you do not want to be marked.

**Information**
- The maximum mark for this paper is 30.
- The marks for questions are shown in brackets.
- A *Data Sheet* is provided as a loose insert to this question paper.
- You are expected to use a calculator where appropriate.
- You are advised to spend no more than 30 minutes on Question 1.

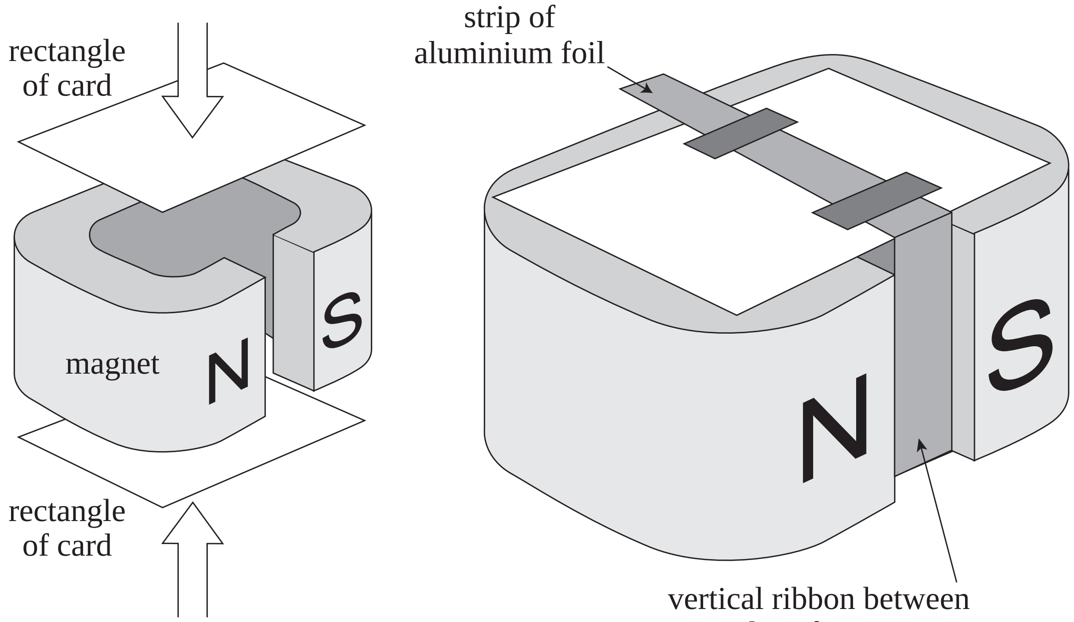
| For Examiner's Use | | | |
|---|---|---|---|
| Question | Mark | Question | Mark |
| 1 | | | |
| 2 | | | |
| Total (Column 1) | | | |
| Total (Column 2) | | | |
| TOTAL | | | |
| Examiner's Initials | | | |

Answer **both** questions.

You are advised to spend no more than 30 minutes on Question 1.

**1** A model of a device called a ribbon microphone is constructed, as illustrated in **Figure 1**.

**Figure 1**




Rectangles of card are glued to the top and bottom of a powerful U-shaped magnet. A strip of aluminium foil is positioned around the arrangement so that the vertical part, called the 'ribbon', is fixed between the pole pieces of the magnet. The horizontal parts of the foil are taped on to the rectangles of card.

Sound from a loudspeaker connected to a variable frequency ac supply is incident on the ribbon. The vibrations produced in the ribbon cause an alternating voltage to be induced between the ends of the aluminium foil.

The sensitivity of the ribbon microphone changes as the frequency of the incident sound is varied, with maximum sensitivity occurring when the ribbon resonates.

You are asked to design a detailed investigation into how the sensitivity of the microphone varies with the frequency of the incident sound and hence determine the resonant frequency of the ribbon.

You have access to the normal laboratory apparatus used in schools and colleges. Your method should take account of the fact that the calibration of some variable frequency ac supplies is not reliable and the indicated frequency of the output pd may not be correct. Taking into account the limitations of the apparatus, describe a suitable procedure for the investigation you have been asked to carry out.

In your answer you should

- identify the quantities that will be measured and explain how these measurements will be made,
- explain how the measurements will be used to determine the resonant frequency of the ribbon,
- list any factor(s) that should be controlled during the proposed experiment and explain how this will be done,
- identify any difficulties in obtaining reliable results that might be encountered and explain relevant procedures that will enable these difficulties to be overcome; it may be helpful to illustrate such procedures with the aid of a diagram or sketch.

Write your answer to Question 1 on **pages 4 and 5** of this booklet.

*(8 marks)*

Areas outside the box will not be scanned for marking

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**There are no questions printed on this page**

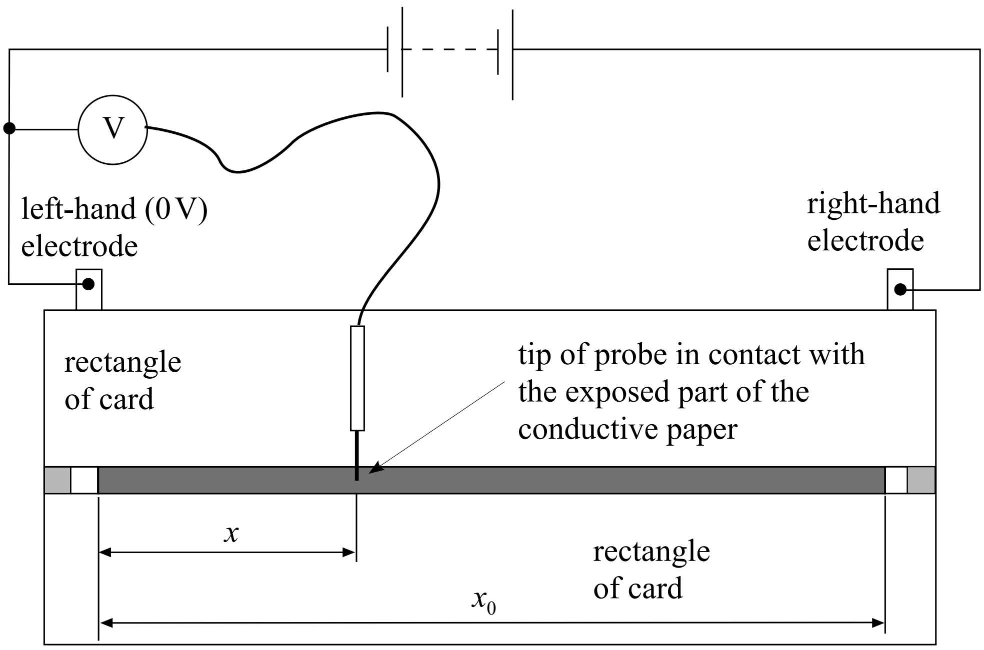
**DO NOT WRITE ON THIS PAGE**
**ANSWER IN THE SPACES PROVIDED**

**2** In this experiment you are to investigate the variation of electrical potential along a strip of conductive paper, most of which is concealed from view.
This strip consists of three regions; within each region, the width of the paper is either constant or varies linearly. Possible examples are shown in **Figure 3 on page 10**.
**Do not remove the rectangles of card concealing most of the conductive paper**.

**No description of the experiment is required**.

You are provided with the apparatus shown in **Figure 2**.

**Figure 2**




Electric connections are made to the conductive paper via two copper foil electrodes.
A dc voltage is applied between these electrodes with the left-hand electrode at 0 V.
The negative terminal of a digital voltmeter has been connected to the 0 V electrode.
The positive terminal of the voltmeter is connected to a probe, the tip of which may be placed at any point on the exposed part of the conductive paper. The voltmeter reading then shows the electrical potential at a perpendicular distance, $x$, between the tip of the probe and the left-hand electrode.

**2** (a) Measure and record the distance $x_0$, as shown in **Figure 2**.

$x_0$= ....................................

*(1 mark)*

**Question 2 continues on the next page**

**2** (b) (i) Place the tip of the probe in contact with the exposed part of the conductive paper at a point approximately 10 mm from the **left-hand** (0 V) electrode.
Measure (and record in the space below part (b)(iii)) the electrical potential, $V$, and the distance, $x$, between the tip of the probe and the left-hand electrode.

**2** (b) (ii) Place the tip of the probe in contact with the exposed part of the conductive paper at a point approximately 10 mm from the **right-hand** electrode.
Measure (and record in the space below part (b)(iii)) the new readings of $V$ and $x$.

**2** (b) (iii) Measure (and record) additional readings of $V$ and $x$ by placing the tip of the probe in contact with the conductive paper at various points **between the positions** identified in part (b)(i) and part (b)(ii).
You should take sufficient readings so that when a graph is plotted of these data, you can establish clearly how $V$ varies with $x$ in each of the three regions of the strip.

**Measurements and observations**

*(7 marks)*

**2** (c) Plot a graph using all the measurements made in part (b) with $V$ on the vertical axis and $x$ on the horizontal axis.

*(5 marks)*

**2** (d) (i) Measure and record the gradient, $G_1$, of your graph where $x = 40$ mm.

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$G_1$ = ..................................

**2** (d) (ii) Measure and record the gradient, $G_2$, of your graph where $x = 240$ mm.

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$G_2$ = ..................................

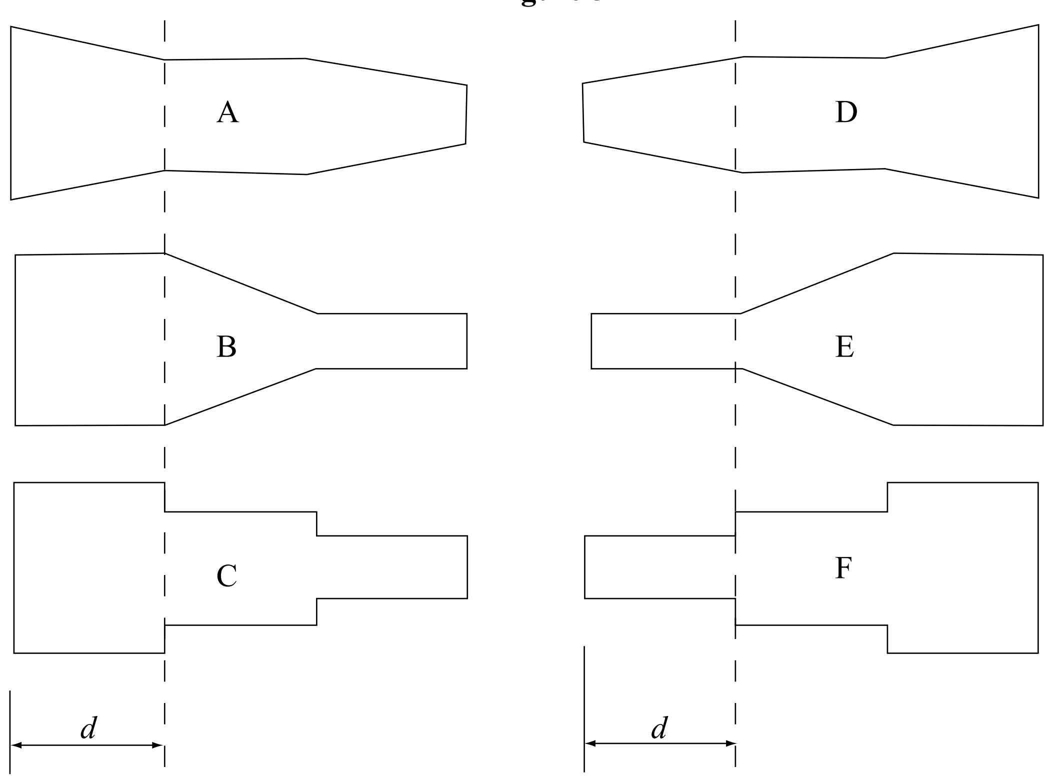
**2** (d) (iii) Evaluate $\frac{G_1}{G_2}$.

$\frac{G_1}{G_2}$ = ..................................

*(3 marks)*

**2** (e) **Figure 3**, which is not to scale, shows some possible shapes of the conductive paper strip you used. In each diagram, the 0 V electrode is on the left, as in the experiment you performed.

**Figure 3**



**2** (e) (i) Explain which sketch, A to F, best represents the shape of the conductive paper used in your experiment.

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**2** (e) (ii) Based on the evidence of your graph, estimate the distance $d$, shown in **Figure 3**.

$d$ = ....................................

*(4 marks)*

**2** (f) Suppose you were to repeat the experiment using a power supply of lower emf. State and explain what effect, if any, this would have on your result for $\frac{G_1}{G_2}$.

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*(2 marks)*

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**END OF QUESTIONS**

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**ANSWER IN THE SPACES PROVIDED**

General Certificate of Education
June 2008
Advanced Subsidiary Examination

**PHYSICS (SPECIFICATION A)** **PHAP**
**Practical (Units 5–9)**
**Data Sheet**

## Fundamental constants and values

| *Quantity* | *Symbol* | *Value* | *Units* |
|---|---|---|---|
| speed of light in vacuo | $c$ | $3.00 \times 10^{8}$ | $\mathrm{m\ s^{-1}}$ |
| permeability of free space | $\mu_0$ | $4\pi \times 10^{-7}$ | $\mathrm{H\ m^{-1}}$ |
| permittivity of free space | $\varepsilon_0$ | $8.85 \times 10^{-12}$ | $\mathrm{F\ m^{-1}}$ |
| charge of electron | $e$ | $1.60 \times 10^{-19}$ | C |
| the Planck constant | $h$ | $6.63 \times 10^{-34}$ | J s |
| gravitational constant | $G$ | $6.67 \times 10^{-11}$ | $\mathrm{N\ m^{2}\ kg^{-2}}$ |
| the Avogadro constant | $N_A$ | $6.02 \times 10^{23}$ | $\mathrm{mol^{-1}}$ |
| molar gas constant | $R$ | 8.31 | $\mathrm{J\ K^{-1}\ mol^{-1}}$ |
| the Boltzmann constant | $k$ | $1.38 \times 10^{-23}$ | $\mathrm{J\ K^{-1}}$ |
| the Stefan constant | $\sigma$ | $5.67 \times 10^{-8}$ | $\mathrm{W\ m^{-2}\ K^{-4}}$ |
| the Wien constant | $\alpha$ | $2.90 \times 10^{-3}$ | m K |
| electron rest mass (equivalent to $5.5 \times 10^{-4}$u) | $m_e$ | $9.11 \times 10^{-31}$ | kg |
| electron charge/mass ratio | $e/m_e$ | $1.76 \times 10^{11}$ | $\mathrm{C\ kg^{-1}}$ |
| proton rest mass (equivalent to 1.00728u) | $m_p$ | $1.67 \times 10^{-27}$ | kg |
| proton charge/mass ratio | $e/m_p$ | $9.58 \times 10^{7}$ | $\mathrm{C\ kg^{-1}}$ |
| neutron rest mass (equivalent to 1.00867u) | $m_n$ | $1.67 \times 10^{-27}$ | kg |
| gravitational field strength | $g$ | 9.81 | $\mathrm{N\ kg^{-1}}$ |
| acceleration due to gravity | $g$ | 9.81 | $\mathrm{m\ s^{-2}}$ |
| atomic mass unit (1u is equivalent to 931.3 MeV) | u | $1.661 \times 10^{-27}$ | kg |

## Fundamental particles

| *Class* | *Name* | *Symbol* | *Rest energy* /MeV |
|---|---|---|---|
| photon | photon | $\gamma$ | 0 |
| lepton | neutrino | $\nu_e$ | 0 |
| | | $\nu_\mu$ | 0 |
| | electron | $e^{\pm}$ | 0.510999 |
| | muon | $\mu^{\pm}$ | 105.659 |
| mesons | pion | $\pi^{\pm}$ | 139.576 |
| | | $\pi^{0}$ | 134.972 |
| | kaon | $K^{\pm}$ | 493.821 |
| | | $K^{0}$ | 497.762 |
| baryons | proton | p | 938.257 |
| | neutron | n | 939.551 |

## Properties of quarks

| *Type* | *Charge* | *Baryon number* | *Strangeness* |
|---|---|---|---|
| u | $+\frac{2}{3}$ | $+\frac{1}{3}$ | 0 |
| d | $-\frac{1}{3}$ | $+\frac{1}{3}$ | 0 |
| s | $-\frac{1}{3}$ | $+\frac{1}{3}$ | –1 |

## Geometrical equations

*arc length* $= r\theta$

*circumference of circle* $= 2\pi r$

*area of circle* $= \pi r^2$

*area of cylinder* $= 2\pi rh$

*volume of cylinder* $= \pi r^2 h$

*area of sphere* $= 4\pi r^2$

*volume of sphere* $= \frac{4}{3}\pi r^3$

## Mechanics and Applied Physics

$v = u + at$

$s = \left(\frac{u+v}{2}\right)t$

$s = ut + \frac{at^2}{2}$

$v^2 = u^2 + 2as$

$F = \frac{\Delta(mv)}{\Delta t}$

$P = Fv$

$efficiency = \frac{power\ output}{power\ input}$

$\omega = \frac{v}{r} = 2\pi f$

$a = \frac{v^2}{r} = r\omega^2$

$I = \sum mr^2$

$E_k = \frac{1}{2} I\omega^2$

$\omega_2 = \omega_1 + \alpha t$

$\theta = \omega_1 t + \frac{1}{2}\alpha t^2$

$\omega_2^2 = \omega_1^2 + 2\alpha\theta$

$\theta = \frac{1}{2}(\omega_1 + \omega_2)t$

$T = I\alpha$

*angular momentum* $= I\omega$

$W = T\theta$

$P = T\omega$

*angular impulse = change of angular momentum* $= Tt$

$\Delta Q = \Delta U + \Delta W$

$\Delta W = p\Delta V$

$pV^{\gamma} = \text{constant}$

*work done per cycle = area of loop*

*input power = calorific value × fuel flow rate*

*indicated power as (area of p – V loop) × (no. of cycles/s) × (no. of cylinders)*

*friction power = indicated power – brake power*

$efficiency = \frac{W}{Q_{in}} = \frac{Q_{in} - Q_{out}}{Q_{in}}$

*maximum possible efficiency* $= \frac{T_H - T_C}{T_H}$

## Fields, Waves, Quantum Phenomena

$g = \frac{F}{m}$

$g = -\frac{GM}{r^2}$

$g = -\frac{\Delta V}{\Delta x}$

$V = -\frac{GM}{r}$

$a = -(2\pi f)^2 x$

$v = \pm 2\pi f\sqrt{A^2 - x^2}$

$x = A\cos 2\pi ft$

$T = 2\pi\sqrt{\frac{m}{k}}$

$T = 2\pi\sqrt{\frac{l}{g}}$

$\lambda = \frac{\omega s}{D}$

$d\sin\theta = n\lambda$

$\theta \approx \frac{\lambda}{D}$

${}_1n_2 = \frac{\sin\theta_1}{\sin\theta_2} = \frac{c_1}{c_2}$

${}_1n_2 = \frac{n_2}{n_1}$

$\sin\theta_c = \frac{1}{n}$

$E = hf$

$hf = \phi + E_k$

$hf = E_1 - E_2$

$\lambda = \frac{h}{p} = \frac{h}{mv}$

$c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$

## Electricity

$\epsilon = \frac{E}{Q}$

$\epsilon = I(R + r)$

$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$

$R_T = R_1 + R_2 + R_3 + \cdots$

$P = I^2 R$

$E = \frac{F}{Q} = \frac{V}{d}$

$E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$

$E = \frac{1}{2}QV$

$F = BIl$

$F = BQv$

$Q = Q_0 e^{-t/RC}$

$\Phi = BA$

magnitude of induced emf $= N \dfrac{\Delta \Phi}{\Delta t}$

$I_{rms} = \dfrac{I_0}{\sqrt{2}}$

$V_{rms} = \dfrac{V_0}{\sqrt{2}}$

**Mechanical and Thermal Properties**

the Young modulus $= \dfrac{\text{tensile stress}}{\text{tensile strain}} = \dfrac{F}{A}\,\dfrac{l}{e}$

energy stored $= \frac{1}{2} Fe$

$\Delta Q = mc\,\Delta\theta$

$\Delta Q = ml$

$pV = \frac{1}{3} Nm\overline{c^2}$

$\frac{1}{2} m\overline{c^2} = \frac{3}{2} kT = \dfrac{3RT}{2N_A}$

**Nuclear Physics and Turning Points in Physics**

force $= \dfrac{eV_p}{d}$

force $= Bev$

radius of curvature $= \dfrac{mv}{Be}$

$\dfrac{eV}{d} = mg$

work done $= eV$

$F = 6\pi\eta rv$

$I = k\dfrac{I_0}{x^2}$

$\dfrac{\Delta N}{\Delta t} = -\lambda N$

$\lambda = \dfrac{h}{\sqrt{2meV}}$

$N = N_0 e^{-\lambda t}$

$T_{\frac{1}{2}} = \dfrac{\ln 2}{\lambda}$

$R = r_0 A^{\frac{1}{3}}$

$E = mc^2 = \dfrac{m_0 c^2}{\left(1 - \dfrac{v^2}{c^2}\right)^{\frac{1}{2}}}$

$l = l_0 \left(1 - \dfrac{v^2}{c^2}\right)^{\frac{1}{2}}$

$t = \dfrac{t_0}{\left(1 - \dfrac{v^2}{c^2}\right)^{\frac{1}{2}}}$

**Astrophysics and Medical Physics**

| Body | Mass/kg | Mean radius/m |
|---|---|---|
| Sun | $2.00 \times 10^{30}$ | $7.00 \times 10^{8}$ |
| Earth | $6.00 \times 10^{24}$ | $6.40 \times 10^{6}$ |

1 astronomical unit $= 1.50 \times 10^{11}$ m

1 parsec = 206265 AU $= 3.08 \times 10^{16}$ m = 3.26 ly

1 light year $= 9.45 \times 10^{15}$ m

Hubble constant ($H$) = 65 km s$^{-1}$ Mpc$^{-1}$

$M = \dfrac{\text{angle subtended by image at eye}}{\text{angle subtended by object at unaided eye}}$

$M = \dfrac{f_o}{f_e}$

$m - M = 5 \log \dfrac{d}{10}$

$\lambda_{max} T = \text{constant} = 0.0029 \text{ m K}$

$v = Hd$

$P = \sigma A T^4$

$\dfrac{\Delta f}{f} = \dfrac{v}{c}$

$\dfrac{\Delta \lambda}{\lambda} = -\dfrac{v}{c}$

$R_s \approx \dfrac{2GM}{c^2}$

**Medical Physics**

power $= \dfrac{1}{f}$

$\dfrac{1}{u} + \dfrac{1}{v} = \dfrac{1}{f}$ and $m = \dfrac{v}{u}$

intensity level $= 10 \log \dfrac{I}{I_0}$

$I = I_0 e^{-\mu x}$

$\mu_m = \dfrac{\mu}{\rho}$

**Electronics**

Resistors

Preferred values for resistors (E24)
Series: 1.0 1.1 1.2 1.3 1.5 1.6 1.8 2.0 2.2 2.4 2.7 3.0 3.3 3.6 3.9 4.3 4.7 5.1 5.6 6.2 6.8 7.5 8.2 9.1 ohms
and multiples that are ten times greater

$Z = \dfrac{V_{rms}}{I_{rms}}$

$\dfrac{1}{C_T} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \dfrac{1}{C_3} + \cdots$

$C_T = C_1 + C_2 + C_3 + \cdots$

$X_C = \dfrac{1}{2\pi fC}$

**Alternating Currents**

$f = \dfrac{1}{T}$

**Operational amplifier**

$G = \dfrac{V_{out}}{V_{in}}$ voltage gain

$G = -\dfrac{R_f}{R_1}$ inverting

$G = 1 + \dfrac{R_f}{R_1}$ non-inverting

$V_{out} = -R_f\left(\dfrac{V_1}{R_1} + \dfrac{V_2}{R_2} + \dfrac{V_3}{R_3}\right)$ summing