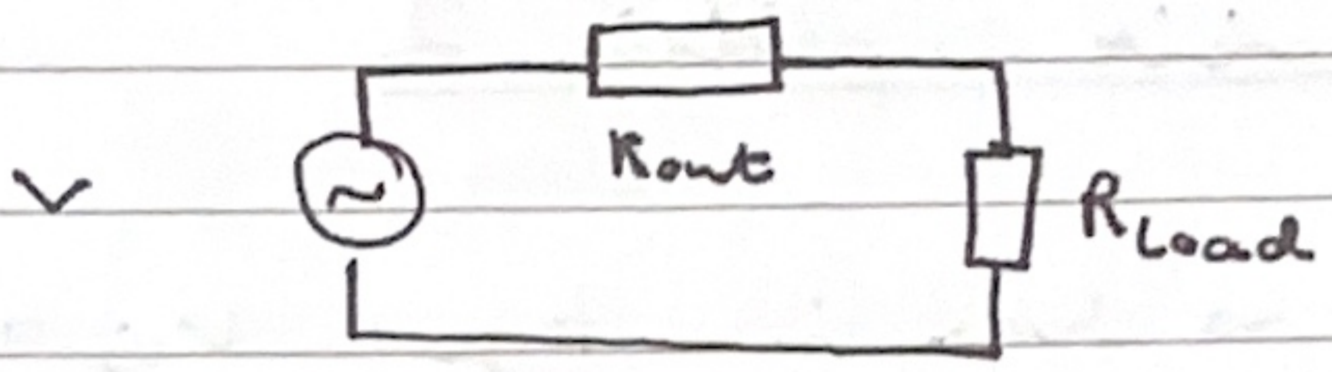
Weeks 1 – 2 ~ Experimental methods.

1 (a)



(i) <u>Voltage across R_{Load}</u>

Potential divider: $\frac{R_{Load}}{R_{Load}+R_{out}} \times V = V_{Load}$

if $R_{Load} >> R_{out}$ $\therefore$ $R_{Load}+R_{out} \rightarrow R_{Load}$

hence $V_{Load} = V \times \frac{R_{Load}}{R_{Load}} = \underbrace{V \times 1 = V}$ //

physical significance: when internal resistance of generator is effectively negligible (or component such as voltmeter - with very high R - is receiving device)

(ii) <u>Max power dissipated in R_{Load}</u>

$P_{load} = V_{load} I_{load}$

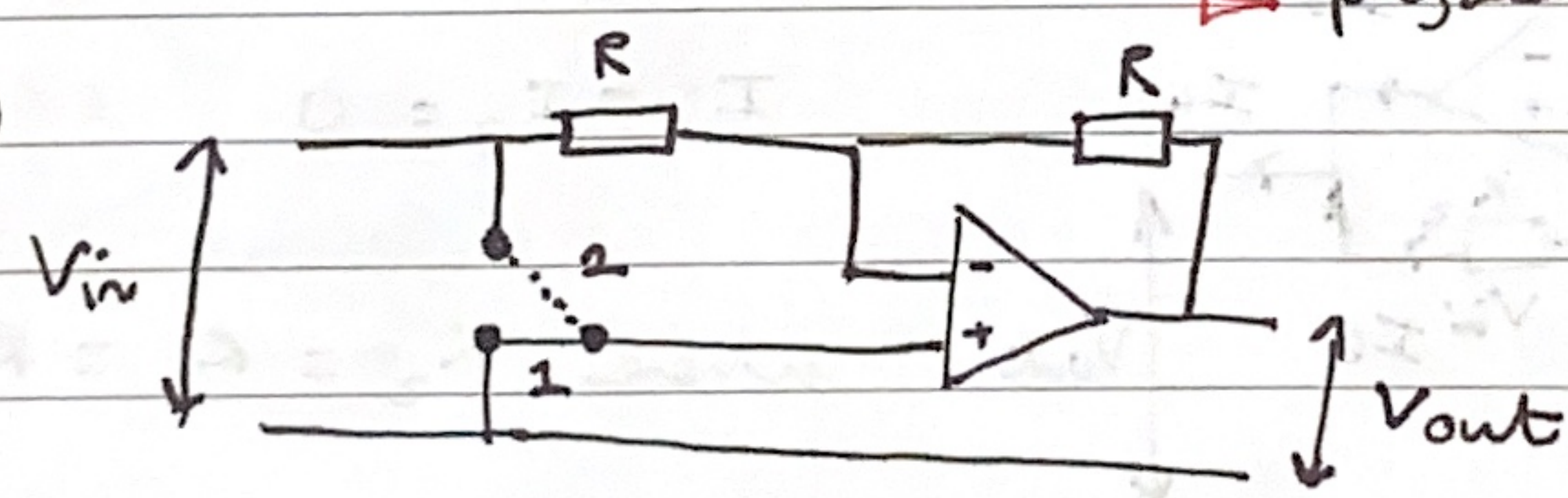
$V_{load} = \frac{V R_{Load}}{R_{out}+R_{Load}} = \frac{V}{2}$

$I = \frac{V}{R_{out}+R_{Load}} = \frac{V}{2R_{Load}}$

hence $P_{load} = \frac{V}{2} \times \frac{V}{2R_{Load}} = \frac{V^2}{4R_{Load}}$ //

physical significance: if input source has large resistance (comparable with 'scopes)

(b)



<u>Behaviour of circuit for position 1</u>

Conventional op-amp set-up: hence $V_{out} = V_{in} \times -\frac{R}{R}$

$= -V_{in}$

the signal has therefore just been reversed in phase.

Behaviour of circuit in position 2

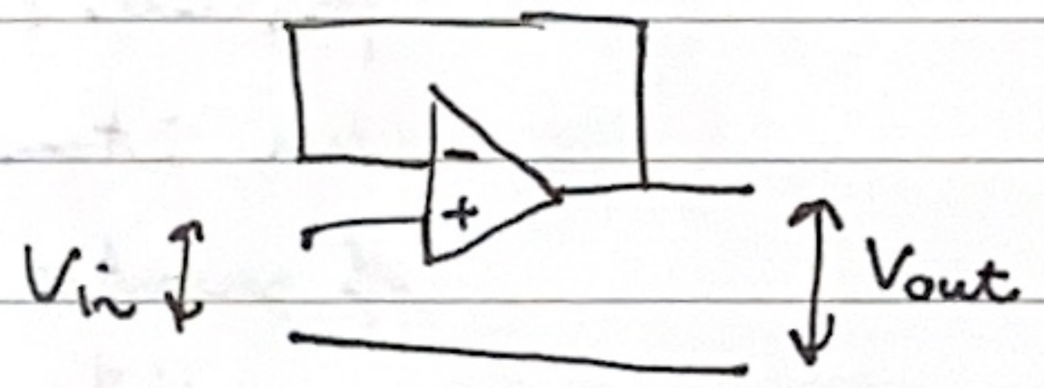
there will be no change in voltage: $V_{in} = V_{out}$

~~(iii)~~ Impact of frequency & V_{in} magnitude on V_{out}.

At high frequencies there will be a decay in output ?

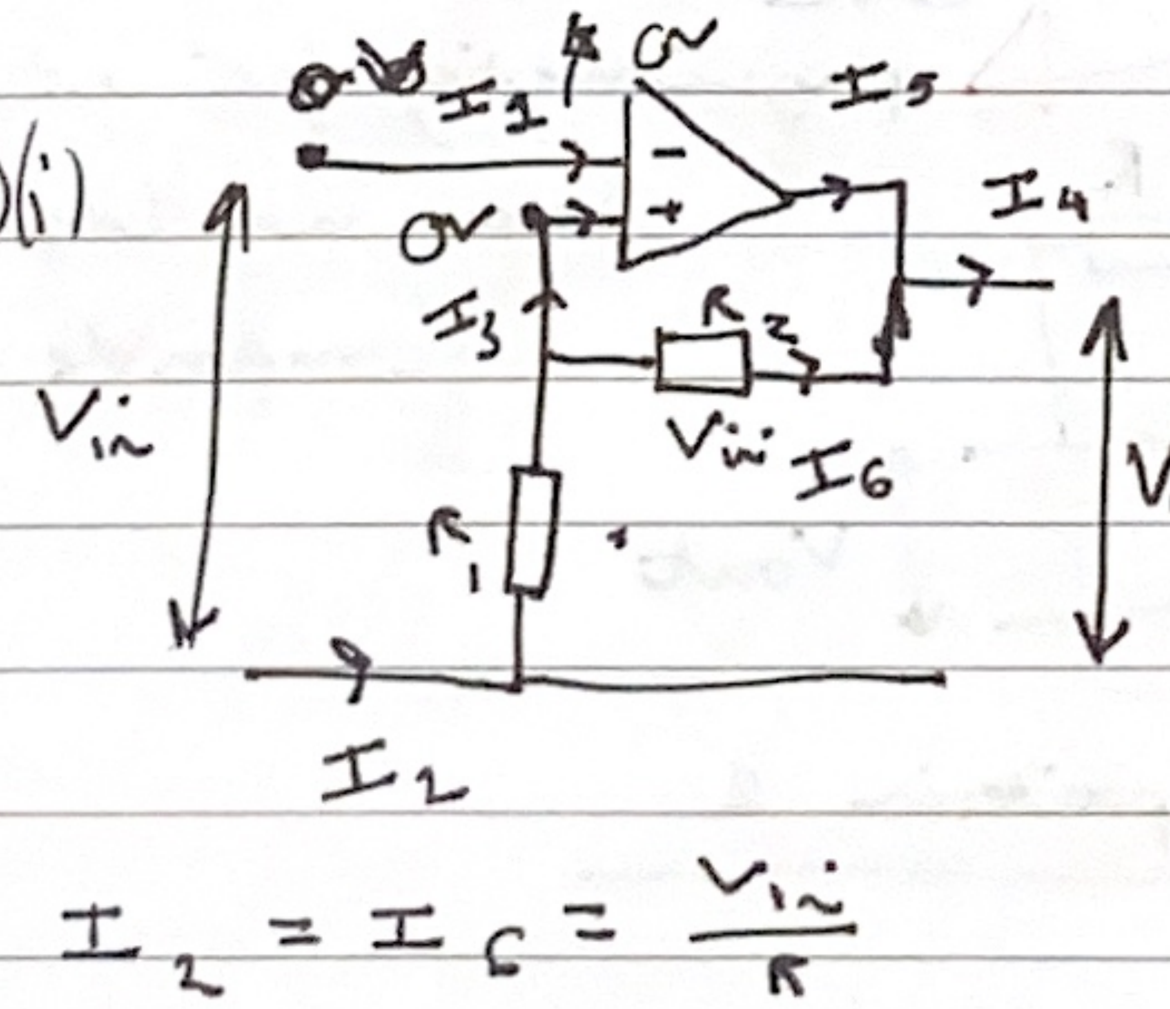
(c) Buffer

~~States~~ GR1: inputs draw no current
G2R: + & − same.
~~GR2~~:



GR2 means that if + input is at V_{in}, so must − input.
GR1 means that the upper wire (into − input) draws no current & so must be in equipotential & hence is V_{in}. $\frac{V_{in}}{V_{in}} = 1$ ∴ unit gain. Must have infinite input impedance or shortcircuited ?
↳ buffer used to connect circuits ?

(d)(i)



$I_1 = I_3 = 0$

where $R_2 = R_1 = R$

$\frac{V_{in}}{R}$ +

$I_2 = I_6 = \frac{V_{in}}{R}$

$I_4 = I_5 + I_6$

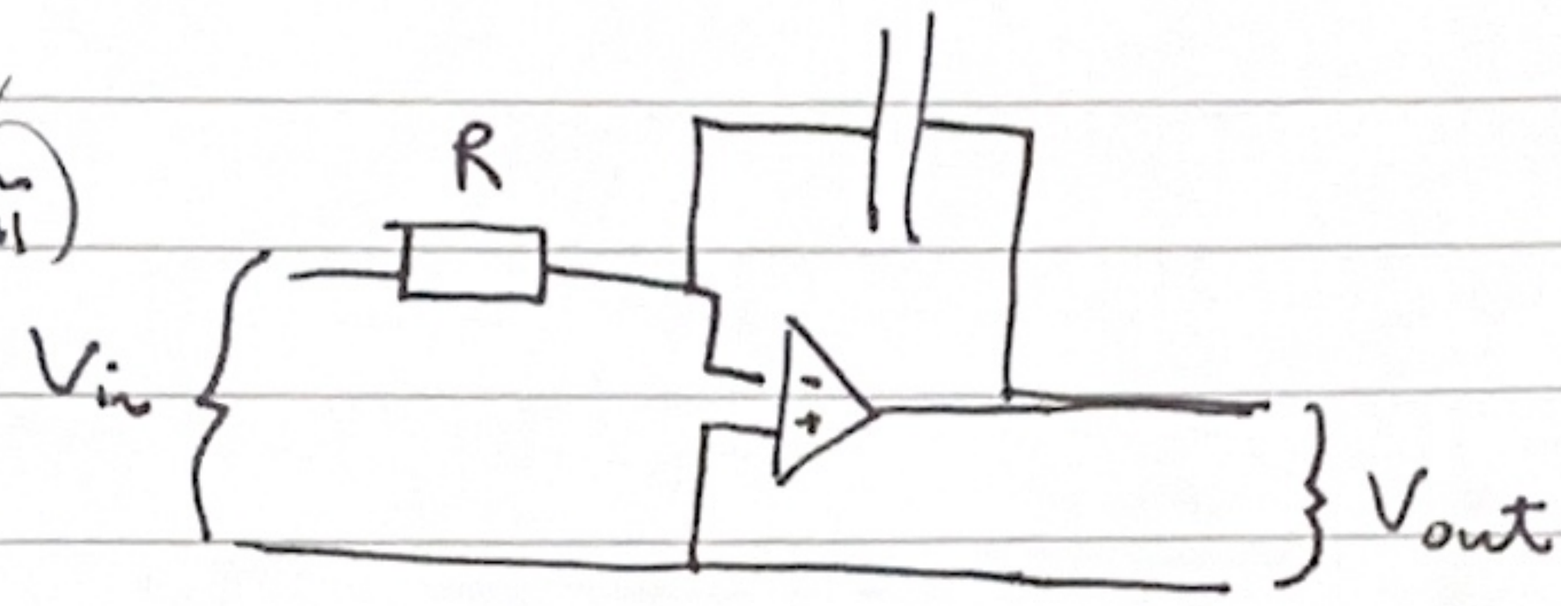
∴ gain of −1

∴ $I_2 \times R$ $\quad \frac{V_{in}}{R} \times R = -V_{in}$

hence $V_{in} = -V_{out}$ → by changing the resistances so if they give different resistances will yield a voltage gain of $-\frac{R_2}{R_1}$

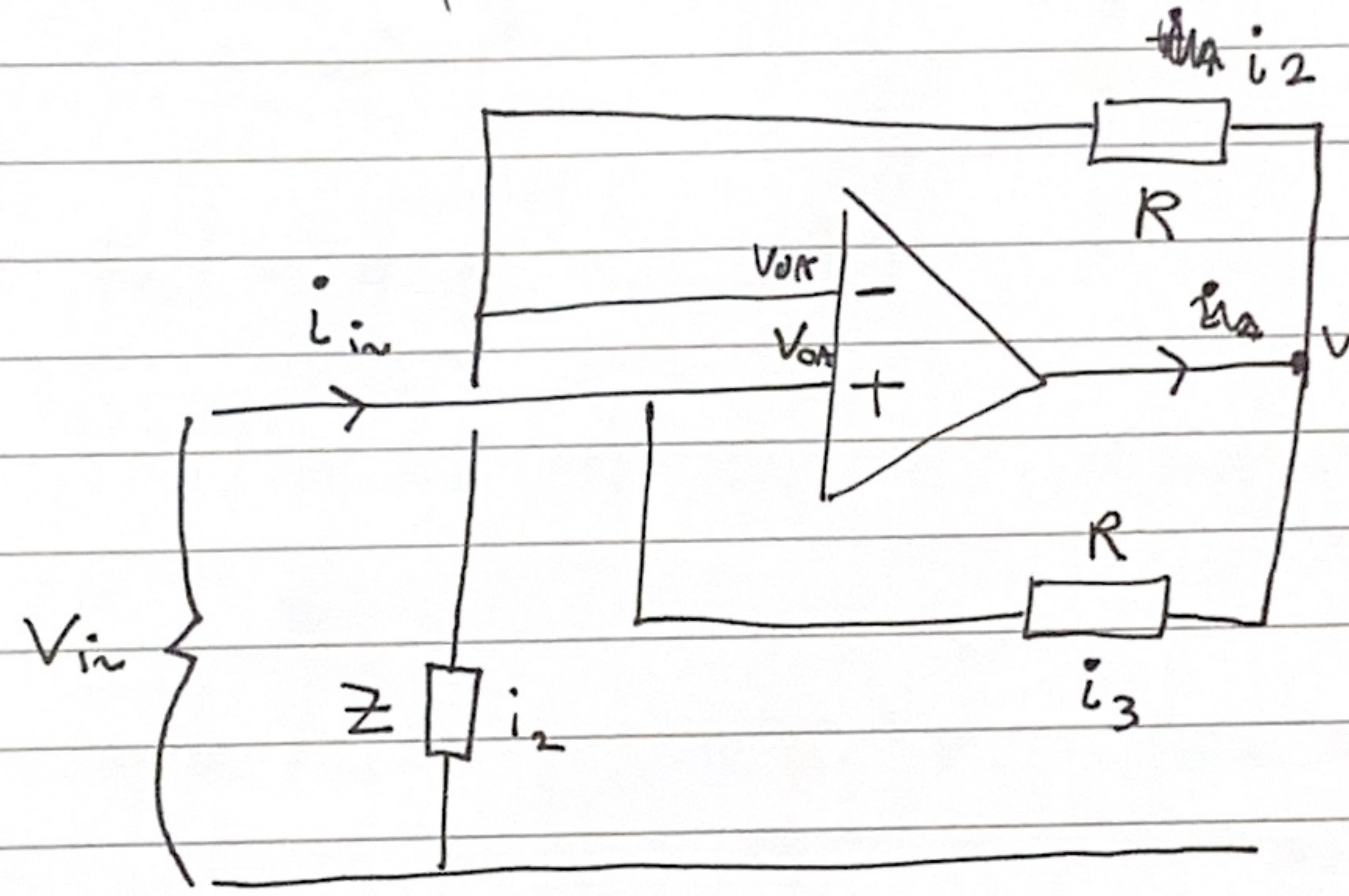
$C \rightsquigarrow Z_c = \frac{-i}{\omega C}$

(ii)



The impedance of the capacitor will → 0 at high ω which would lead to a short circuit. Mitigate by putting resistor in parallel with capacitor?

(2)



"negative impedance converter"

+ Input V = − Input V (as negative feedback present.)

$i_3 = \frac{V_{in} - V_{OR}}{R}$ | $\boxed{\cancel{i_4 = \frac{V_{in}}{R}}}$ | $i_2 = \frac{V_{OR} - V_{in}}{R} = \frac{V_{in}}{Z}$

$\boxed{\cancel{i_2 = i_{in} - i_3}}$ $\cancel{= \frac{V_{in}}{Z}}$

$-i_3 Z = V_{in}$

$\frac{V_{in}}{i_3} = -Z$

~~Q(8)~~

(Q11) $\psi = Re[C\exp(i(\omega t - kz))] \Rightarrow \frac{\partial\psi}{\partial t} = Re[i\omega C\exp(i(\omega t - kz))]$

$$\cancel{P(t) = Z\left(\frac{\partial\psi}{\partial t}\right)^2 = Re[-\omega^2 C^2 \exp(2i(\omega t - kz))] \times Z = -\omega^2|C|^2}$$

$$Re[A] = \frac{1}{2}(A + A^*)$$

$$\therefore Re[i\omega C\exp(i(\omega t - kz))] = \frac{1}{2}(i\omega C\exp(i(\omega t - zk)) + \omega C^*\exp(-i(\omega t - zk)))$$

square this $\rightarrow \frac{1}{4}(2\omega^2|C|^2 + \ldots$ other terms with $\exp(i\omega t - zk)$ time average $\rightarrow 0$ $\therefore$ can be neglected.

C^*C

$$\left(\frac{\partial\psi}{\partial t}\right)^2 = \frac{\omega^2|C|^2}{2}$$

$$\therefore P(t) = \frac{1}{2}Z\omega^2|C|^2$$

Complex Z $\rightarrow$ this would occur to accomodate stiffness/elasticity in the spring?

$$Re[A]Re[B] = \frac{1}{2}(A + A^*)\frac{1}{2}(B + B^*)$$
$$= \frac{1}{4}(AB + AB^* + B^*A + A^*B^*)$$
$$= \frac{1}{2} Re[AB + AB^*]$$

here $P = \frac{1}{2}Re[-\omega^2 C^2 \exp(2i(\omega t - kz))Z + Z\omega^2 |C|^2 \exp(-2i(\omega t - kz)))$

$= \frac{1}{4}($

Not sure how to get real part of this express...