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3. Solving ODEs with Fourier Series

2. Review the exponential response

Course > Unit 1: Fourier Series > and Signal Processing

> formula

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2. Review the exponential response formula

Recall that the exponential response formula gives us a quick method for finding the particular solution to any linear, constant coefficient, differential equations whose input can be expressed in terms of an exponential function.

The exponential response formula (ERF): Let P be a polynomial with real, constant coefficients, $D=\frac{d}{dt}$ a differential operator, and r a (real or complex) number. If $P(r) \neq 0$, then a particular solution to the inhomogeneous differential equation

$$P\left(D
ight)y=e^{rt} \qquad ext{is given by} \qquad y_p=rac{e^{rt}}{P\left(r
ight)}.$$

Caveat

Caveat: If
$$P\left(r
ight)=P'\left(r
ight)=P''\left(r
ight)=\ldots=P^{(k-1)}\left(r
ight)=0$$
 , but $P^{(k)}\left(r
ight)
eq0$, then a particular solution to $P\left(D
ight)y=e^{rt}$ is given by

$$y_{p}=rac{t^{k}e^{rt}}{P^{\left(k
ight)}\left(r
ight)}.$$

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Sinusoidal input:

$$P(D) x = \cos(\omega t)$$

is the real part of

$$P(D)z=e^{i\omega t}$$
 ;

$$P(D) x = \sin(\omega t)$$

is the imaginary part of

$$P\left(D
ight) z=e^{i\omega t}$$
 .

Therefore

- ullet a particular solution to $P\left(D
 ight)x=\cos\left(\omega t
 ight)$ is given by $x_p=\mathrm{Re}\left[rac{e^{i\omega t}}{P\left(i\omega
 ight)}
 ight]$;
- ullet a particular solution to $P(D)\,x=\sin{(\omega t)}$ is given by $x_p=\mathrm{Im}\,\left[rac{e^{i\omega t}}{P(i\omega)}
 ight].$

2. Review the exponential response formula

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A particular solution

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A particular solution, So I guess we could add a solution of the homogeneous equation P(D) y = 0 to get other solutions using superposition.

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