Information you'll have for the final:

Table of Laplace Transforms

f	$\mathcal{L}[f]$	f	$\mathcal{L}[f]$
1	$\frac{1}{s}$	$\cos bt$	$\frac{s}{s^2+b^2}$
e^{at}	$\frac{1}{s-a}$	$\sin bt$	$\frac{b}{s^2+b^2}$
t^n	$\frac{n!}{s^{n+1}}$	$e^{at}\cos bt$	$\frac{(s-a)}{(s-a)^2+b^2}$
$t^n e^{at}$	$\frac{n!}{(s-a)^{n+1}}$	$e^{at}\sin bt$	$\frac{b}{(s-a)^2+b^2}$

Acceleration Due to Gravity

standard: $g = 32.2$ ft/s^2 (you can use $g = 32$)

metric: $g = 9.8$ m/s^2 (you can use $g = 10$)

1. A tank of water starts with 50 g of dye dissolved in 10 L of water. Solution containing 5 g/L of dye enters the tank at a rate of 6 L/s, mixes with the contents of the tank, and the mixture drains at a rate of 4 L/s.

Find the *concentration* of dye at time t. Find the limiting concentration of dye as $t \to \infty$.

2. (a) Solve the equation

$$\frac{1}{x}y' = e^{x+y}.$$

(b) Solve the equation

$$\frac{1}{x}y' + \frac{2}{x^2}y = \frac{e^x}{x^2}.$$

3. A 2lb weight is attached to a spring, stretching it 4 feet. There is a damping force, which is equal to 40 lb when the weight is traveling at 5 ft/s. There's also an external force $F(t) = \frac{1}{4}\cos 3t$ lb acting on the weight.

(a) Find the quasiperiod of the system and the general solution.

(b) What is the amplitude and phase of the steady-state solution? (Your answer may involve square roots and trigonometric functions.)

(c) Suppose the external force is altered slightly to $F(t) = \frac{1}{4}\cos 2t$. Will the amplitude of the steady state solution increase or decrease? Explain why. (You don't have to find the steady-state solution)

4. Match the initial value problems shown below with the graphs of their solutions:

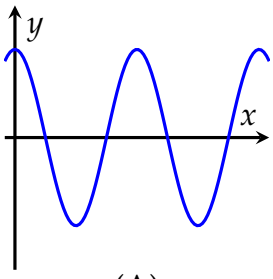
1. $\begin{cases} y'' + 5y' + 6y = 0 \\ y(0) = 1 \\ y'(0) = 0 \end{cases}$

2. $\begin{cases} y'' - 4y' + 6y = 0 \\ y(0) = 1 \\ y'(0) = 0 \end{cases}$

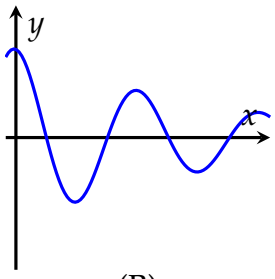
3. $\begin{cases} y'' - 5y' + 6y = 0 \\ y(0) = 1 \\ y'(0) = 0 \end{cases}$

4. $\begin{cases} y'' + 6y = 0 \\ y(0) = 1 \\ y'(0) = 0 \end{cases}$

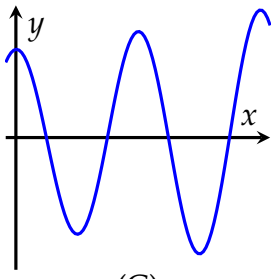
5. $\begin{cases} y'' + 4y' + 6y = 0 \\ y(0) = 1 \\ y'(0) = 0 \end{cases}$



(A)



(B)



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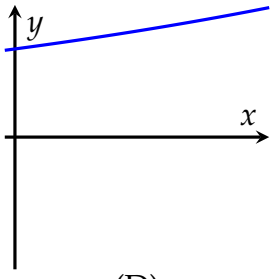

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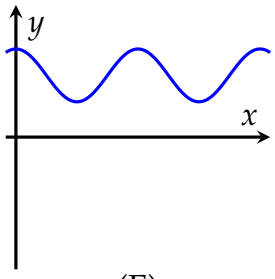
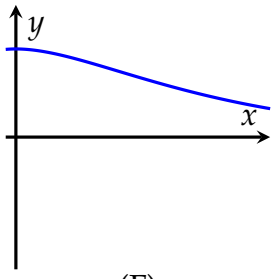


(E)



(F)

5. Solve the initial value problem

$$\begin{aligned} Q'' + 2Q' + 10Q &= E(t) \\ E(t) &= \begin{cases} -10e^{-2t}, & t < \pi \\ 0, & t \geq \pi \end{cases} \\ Q(0) &= 1 \\ Q'(0) &= -3. \end{aligned}$$

6. Find the Laplace transform of $f(t) = t \sin t$, using the definition of the Laplace transform. You can use the facts that $\mathcal{L}\{\sin t\} = \frac{1}{s^2+1}$ and $\mathcal{L}\{\cos t\} = \frac{s}{s^2+1}$.