

1 - 3	4	5	Total

Nome: _____ Cartão: _____

Regras Gerais:

- Não é permitido o uso de calculadoras, telefones ou qualquer outro recurso computacional ou de comunicação.
- Trabalhe individualmente e sem uso de material de consulta além do fornecido.
- Devolva o caderno de questões preenchido ao final da prova.

Regras para as questões abertas:

- Seja sucinto, completo e claro.
- Justifique todo procedimento usado.
- Indique identidades matemáticas usadas, em especial, itens da tabela.
- Use notação matemática consistente.

Identidades:

$\text{sen}(x) = \frac{e^{ix} - e^{-ix}}{2i}$	$\text{cos}(x) = \frac{e^{ix} + e^{-ix}}{2}$
$\text{senh}(x) = \frac{e^x - e^{-x}}{2}$	$\text{cosh}(x) = \frac{e^x + e^{-x}}{2}$
$(a + b)^n = \sum_{j=0}^n \binom{n}{j} a^{n-j} b^j, \quad \binom{n}{j} = \frac{n!}{j!(n-j)!}$	
$\text{sen}(x + y) = \text{sen}(x) \text{cos}(y) + \text{sen}(y) \text{cos}(x)$	
$\text{cos}(x + y) = \text{cos}(x) \text{cos}(y) - \text{sen}(x) \text{sen}(y)$	

Propriedades:

1	Linearidade	$\mathcal{L}\{\alpha f(t) + \beta g(t)\} = \alpha \mathcal{L}\{f(t)\} + \beta \mathcal{L}\{g(t)\}$
2	Transformada da derivada	$\mathcal{L}\{f'(t)\} = s \mathcal{L}\{f(t)\} - f(0)$ $\mathcal{L}\{f''(t)\} = s^2 \mathcal{L}\{f(t)\} - sf(0) - f'(0)$
3	Deslocamento no eixo s	$\mathcal{L}\{e^{at} f(t)\} = F(s - a)$
4	Deslocamento no eixo t	$\mathcal{L}\{u(t - a) f(t - a)\} = e^{-as} F(s)$ $\mathcal{L}\{u(t - a)\} = \frac{e^{-as}}{s}$
5	Transformada da integral	$\mathcal{L}\left\{\int_0^t f(\tau) d\tau\right\} = \frac{F(s)}{s}$
6	Filtragem da Delta de Dirac	$\int_{-\infty}^{\infty} f(t) \delta(t - a) dt = f(a)$
7	Transformada da Delta de Dirac	$\mathcal{L}\{\delta(t - a)\} = e^{-as}$
8	Teorema da Convolação	$\mathcal{L}\{(f * g)(t)\} = F(s)G(s)$, onde $(f * g)(t) = \int_0^t f(\tau)g(t - \tau) d\tau$
9	Transformada de funções periódicas	$\mathcal{L}\{f(t)\} = \frac{1}{1 - e^{-sT}} \int_0^T e^{-s\tau} f(\tau) d\tau$
10	Derivada da transformada	$\mathcal{L}\{t f(t)\} = -\frac{dF(s)}{ds}$
11	Integral da transformada	$\mathcal{L}\left\{\frac{f(t)}{t}\right\} = \int_s^{\infty} F(\hat{s}) \hat{s} d\hat{s}$

Séries:

$\frac{1}{1 - x} = \sum_{n=0}^{\infty} x^n = 1 + x + x^2 + x^3 + \dots, \quad -1 < x < 1$
$\frac{x}{(1 - x)^2} = \sum_{n=1}^{\infty} n x^n = x + 2x^2 + 3x^3 + \dots, \quad -1 < x < 1$
$e^x = \sum_{n=0}^{\infty} \frac{x^n}{n!} = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \dots, \quad -\infty < x < \infty$
$\ln(1 + x) = \sum_{n=0}^{\infty} (-1)^n \frac{x^{n+1}}{n + 1}, \quad -1 < x < 1$
$\arctan(x) = \sum_{n=0}^{\infty} (-1)^n \frac{x^{2n+1}}{2n + 1}, \quad -1 < x < 1$
$\text{sen}(x) = \sum_{n=0}^{\infty} (-1)^n \frac{x^{2n+1}}{(2n + 1)!}, \quad -\infty < x < \infty$
$\text{cos}(x) = \sum_{n=0}^{\infty} (-1)^n \frac{x^{2n}}{(2n)!}, \quad -\infty < x < \infty$
$\text{senh}(x) = \sum_{n=0}^{\infty} \frac{x^{2n+1}}{(2n + 1)!}, \quad -\infty < x < \infty$
$\text{cosh}(x) = \sum_{n=0}^{\infty} \frac{x^{2n}}{(2n)!}, \quad -\infty < x < \infty$
$(1 + x)^m = 1 + \sum_{n=1}^{\infty} \frac{m(m-1) \dots (m-n+1)}{n!} x^n, \quad -1 < x < 1, m \neq 0, 1, 2, \dots$

Funções especiais:

Função Gamma	$\Gamma(k) = \int_0^{\infty} x^{k-1} e^{-x} dx$
Propriedade da Função Gamma	$\Gamma(k + 1) = k \Gamma(k), \quad k > 0$ $\Gamma(n + 1) = n!, \quad n \in \mathbb{N}$
Função de Bessel modificada de ordem ν	$I_{\nu}(x) = \sum_{m=0}^{\infty} \frac{1}{m! \Gamma(m + \nu + 1)} \left(\frac{x}{2}\right)^{2m + \nu}$
Função de Bessel de ordem 0	$J_0(x) = \sum_{m=0}^{\infty} \frac{(-1)^m}{m!^2} \left(\frac{x}{2}\right)^{2m}$
Integral seno	$\text{Si}(t) = \int_0^t \frac{\text{sen}(x)}{x} dx$

Integrais:

$\int x e^{\lambda x} dx = \frac{e^{\lambda x}}{\lambda^2} (\lambda x - 1) + C$
$\int x^2 e^{\lambda x} dx = e^{\lambda x} \left(\frac{x^2}{\lambda} - \frac{2x}{\lambda^2} + \frac{2}{\lambda^3}\right) + C$
$\int x^n e^{\lambda x} dx = \frac{1}{\lambda} x^n e^{\lambda x} - \frac{n}{\lambda} \int x^{n-1} e^{\lambda x} dx + C$
$\int x \cos(\lambda x) dx = \frac{\cos(\lambda x) + \lambda x \text{sen}(\lambda x)}{\lambda^2} + C$
$\int x \text{sen}(\lambda x) dx = \frac{\text{sen}(\lambda x) - \lambda x \text{cos}(\lambda x)}{\lambda^2} + C$
$\int e^{\lambda x} \text{sen}(w x) dx = \frac{e^{\lambda x} (\lambda \text{sen}(w x) - w \text{cos}(w x))}{\lambda^2 + w^2}$

Tabela de transformadas de Laplace:

	$F(s) = \mathcal{L}\{f(t)\}$	$f(t) = \mathcal{L}^{-1}\{F(s)\}$
1	$\frac{1}{s}$	1
2	$\frac{1}{s^2}$	t
3	$\frac{1}{s^n}, \quad (n = 1, 2, 3, \dots)$	$\frac{t^{n-1}}{(n-1)!}$
4	$\frac{1}{\sqrt{s}}$	$\frac{1}{\sqrt{\pi t}}$
5	$\frac{1}{s^{\frac{3}{2}}}$	$2\sqrt{\frac{t}{\pi}}$
6	$\frac{1}{s^k}, \quad (k > 0)$	$\frac{t^{k-1}}{\Gamma(k)}$
7	$\frac{1}{s-a}$	e^{at}
8	$\frac{1}{(s-a)^2}$	te^{at}
9	$\frac{1}{(s-a)^n}, \quad (n = 1, 2, 3, \dots)$	$\frac{1}{(n-1)!} t^{n-1} e^{at}$
10	$\frac{1}{(s-a)^k}, \quad (k > 0)$	$\frac{1}{\Gamma(k)} t^{k-1} e^{at}$
11	$\frac{1}{(s-a)(s-b)}, \quad (a \neq b)$	$\frac{1}{a-b} (e^{at} - e^{bt})$
12	$\frac{s}{(s-a)(s-b)}, \quad (a \neq b)$	$\frac{1}{a-b} (ae^{at} - be^{bt})$
13	$\frac{1}{s^2 + w^2}$	$\frac{1}{w} \text{sen}(wt)$
14	$\frac{s}{s^2 + w^2}$	$\cos(wt)$
15	$\frac{1}{s^2 - a^2}$	$\frac{1}{a} \text{senh}(at)$
16	$\frac{s}{s^2 - a^2}$	$\cosh(at)$
17	$\frac{1}{(s-a)^2 + w^2}$	$\frac{1}{w} e^{at} \text{sen}(wt)$
18	$\frac{s-a}{(s-a)^2 + w^2}$	$e^{at} \cos(wt)$
19	$\frac{1}{s(s^2 + w^2)}$	$\frac{1}{w^2} (1 - \cos(wt))$
20	$\frac{1}{s^2(s^2 + w^2)}$	$\frac{1}{w^3} (wt - \text{sen}(wt))$
21	$\frac{1}{(s^2 + w^2)^2}$	$\frac{1}{2w^3} (\text{sen}(wt) - wt \cos(wt))$
22	$\frac{s}{(s^2 + w^2)^2}$	$\frac{t}{2w} \text{sen}(wt)$
23	$\frac{s^2}{(s^2 + w^2)^2}$	$\frac{1}{2w} (\text{sen}(wt) + wt \cos(wt))$
24	$\frac{s}{(s^2 + a^2)(s^2 + b^2)}, \quad (a^2 \neq b^2)$	$\frac{1}{b^2 - a^2} (\cos(at) - \cos(bt))$
25	$\frac{1}{(s^4 + 4a^4)}$	$\frac{1}{4a^3} [\text{sen}(at) \cosh(at) - \cos(at) \text{senh}(at)]$
26	$\frac{s}{(s^4 + 4a^4)}$	$\frac{1}{2a^2} \text{sen}(at) \text{senh}(at)$
27	$\frac{1}{(s^4 - a^4)}$	$\frac{1}{2a^3} (\text{senh}(at) - \text{sen}(at))$
28	$\frac{s}{(s^4 - a^4)}$	$\frac{1}{2a^2} (\cosh(at) - \cos(at))$

	$F(s) = \mathcal{L}\{f(t)\}$	$f(t) = \mathcal{L}^{-1}\{F(s)\}$
29	$\sqrt{s-a} - \sqrt{s-b}$	$\frac{1}{2\sqrt{\pi t^3}} (e^{bt} - e^{at})$
30	$\frac{1}{\sqrt{s+a}\sqrt{s+b}}$	$e^{\frac{-(a+b)t}{2}} I_0\left(\frac{a-b}{2}t\right)$
31	$\frac{1}{\sqrt{s^2+a^2}}$	$J_0(at)$
32	$\frac{s}{(s-a)^{\frac{3}{2}}}$	$\frac{1}{\sqrt{\pi t}} e^{at} (1 + 2at)$
33	$\frac{1}{(s^2-a^2)^k}, \quad (k > 0)$	$\frac{\sqrt{\pi}}{\Gamma(k)} \left(\frac{t}{2a}\right)^{k-\frac{1}{2}} I_{k-\frac{1}{2}}(at)$
34	$\frac{1}{s} e^{-\frac{k}{s}}, \quad (k > 0)$	$J_0(2\sqrt{kt})$
35	$\frac{1}{\sqrt{s}} e^{-\frac{k}{s}}$	$\frac{1}{\sqrt{\pi t}} \cos(2\sqrt{kt})$
36	$\frac{1}{s^{\frac{3}{2}}} e^{-\frac{k}{s}}$	$\frac{1}{\sqrt{\pi t}} \text{senh}(2\sqrt{kt})$
37	$e^{-k\sqrt{s}}, \quad (k > 0)$	$\frac{k}{2\sqrt{\pi t^3}} e^{-\frac{k^2}{4t}}$
38	$\frac{1}{s} \ln(s)$	$-\ln(t) - \gamma, \quad (\gamma \approx 0,5772)$
39	$\ln\left(\frac{s-a}{s-b}\right)$	$\frac{1}{t} (e^{bt} - e^{at})$
40	$\ln\left(\frac{s^2+w^2}{s^2}\right)$	$\frac{2}{t} (1 - \cos(wt))$
41	$\ln\left(\frac{s^2-a^2}{s^2}\right)$	$\frac{2}{t} (1 - \cosh(at))$
42	$\tan^{-1}\left(\frac{w}{s}\right)$	$\frac{1}{t} \text{sen}(wt)$
43	$\frac{1}{s} \cot^{-1}(s)$	$\text{Si}(t)$
44	$\frac{1}{s} \tanh\left(\frac{as}{2}\right)$	<p>Onda quadrada</p> $f(t) = \begin{cases} 1, & 0 < t < a \\ -1, & a < t < 2a \end{cases}$ $f(t+2a) = f(t), \quad t > 0$
45	$\frac{1}{as^2} \tanh\left(\frac{as}{2}\right)$	<p>Onda triangular</p> $f(t) = \begin{cases} \frac{t}{a}, & 0 < t < a \\ -\frac{t}{a} + 2, & a < t < 2a \end{cases}$ $f(t+2a) = f(t), \quad t > 0$
46	$\frac{w}{(s^2+w^2)\left(1-e^{-\frac{\pi}{w}s}\right)}$	<p>Retificador de meia onda</p> $f(t) = \begin{cases} \text{sen}(wt), & 0 < t < \frac{\pi}{w} \\ 0, & \frac{\pi}{w} < t < \frac{2\pi}{w} \end{cases}$ $f\left(t + \frac{2\pi}{w}\right) = f(t), \quad t > 0$
47	$\frac{w}{s^2+w^2} \coth\left(\frac{\pi s}{2w}\right)$	<p>Retificador de onda completa</p> $f(t) = \text{sen}(wt) $
48	$\frac{1}{as^2} - \frac{e^{-as}}{s(1-e^{-as})}$	<p>Onda dente de serra</p> $f(t) = \frac{t}{a}, \quad 0 < t < a$ $f(t) = f(t-a), \quad t > a$

