ENGR 2910-101
HW01 SOLUTIONS

1) (a) Car B has dead battery as the current (i) is flowing from Car A to Car B

(b) $w(t) = \int_0^t p \, dt$

$p = vi = (12V)(40A) = 480W$

$w(t) = \int_0^{90} (480W) \, dt$

$= (480 W)(90 s)$

$= 43{,}200 J$ or $43.2 kJ$

2) NOTE: If Power is positive, $\boxed{B}$ is absorbing

a) $p = (30V)(6A) = 180 W$ $A \to B$

b) $p = (-20V)(-8A) = 160 W$ $A \to B$

c) $p = (-60V)(4A) = -240W \Rightarrow 240W$ $B \to A$

d) $p = (40V)(-9A) = -360W \Rightarrow 360 W$ $B \to A$

3) $p = vi = t(1 - 0.025t)(4 - 0.2t)$

$= 4t - 0.3t^2 + 0.005t^3$ (W)

a) power is max/min at $dp/dt = \emptyset$

$\frac{dp}{dt} = 4 - 0.6t + 0.015t^2$

$= 0.015(t^2 - 40t + 266.67)$

$t^2 - 40t + 266.67 = \emptyset$

$\Rightarrow t_1 = 8.453 s$ or $t_2 = 31.547 s$

Substituting into $p(t)$

$p(t_1) = 15.396W$

$p(t_2) = -15.396W$

$\boxed{P_{max} \text{ at } t = 8.453 s}$

b) $\boxed{p(8.453) = 15.396\,W}$

c) Maximum power extracted is most negative power. Per (−)

$p = $ max extracted at $\boxed{t = 31.547\,s}$

d) $\boxed{p(31.547\,s) = -15.396\,W}$

e) ~~NET POWER~~ TOTAL ENERGY DELIVERED

$$w = \int_0^t p(t)\,dt$$

$$= \int_0^t (4t - 0.3t^2 + 0.005t^3)\,dt$$

$$= 2t^2 - 0.1t^3 + 0.00125\,t^4 \Big|_0^t$$

$t=0 \Rightarrow w(0) = 0\ J$

$t=10 \Rightarrow w(10) = 112.5\,J$

$t=20 \Rightarrow w(20) = 200\ J$

$t=30 \Rightarrow w(30) = 112.5\,J$

$t=40 \Rightarrow w(40) = 0\ J$

4) $p = vi = \left[(1500t+1)e^{-750t}\right]\left[40e^{-750t}\right]$ (mW)

$\uparrow$ $40\,mA = 0.04\,A$

$$= (60t + 0.04)\,e^{-1500t} \quad (W)$$

$\frac{dp}{dt} \Rightarrow$ use product rule $\frac{d}{dx}f(x)g(x) = f'(x)g(x) + f(x)g'(x)$

$f(x) = 60x + 0.04 \qquad f'(x) = 60$

$g(x) = e^{-1500x} \qquad g'(x) = -1500\,e^{-1500x}$

$$\Rightarrow \frac{dp}{dt} = 60e^{-1500t} - 1500(60t + 0.04)e^{-1500t}$$

$$= -90{,}000\,t\,e^{-1500t}$$

a) $\frac{dp}{dt} = 0 \Rightarrow$ at $t=0$

$\boxed{p_{max} \text{ at } t=0}$

b) $p_{max} = p(0) = [(60)(0) + 0.04]e^0 = 0.04$

$$\boxed{p_{max} = 40 mW}$$

c) $w = \int p\,dt$

$$w_{total} = \int_0^\infty p\,dt$$

$$= \int_0^\infty 60te^{-1500t}\,dt + \int_0^\infty 0.04e^{-1500t}\,dt$$

$$= \frac{60}{(-1500)^2}(-1500t - 1)e^{-1500t} + \frac{0.04}{-1500}e^{-1500t}\Big|_0^\infty$$

NOTE $e^{-\infty} = 0$

$$\Rightarrow w_{total} = -\left(-\frac{60}{(-1500)^2} + \frac{0.04}{-1500}\right)$$

$$\boxed{= 53.33 \mu J}$$

5) FROM THE DIAGRAM

a) $V = -iR$

$i = -v/R = \frac{-40}{2500} = -0.016 A = -16 mA$

b) $p = i^2R = (0.016)^2(2500) = 640 mW$

c) $v = iR$

$i = v/R = 16 mA$

d) $p = i^2R = 640 mW$