HW31

1) TTL inverter:

a) $V_{IL} = V_{BE(OFF)} - V_{CE(SAT)}$
$= .5V - .2V$
$= \boxed{.3V}$

b) $V_{B1} = V_{IL} + V_{BE(ON)}$
$= .3V + 0.7V$
$= 1V$

$I_{IL} = \frac{5-1}{2k} = \boxed{2mA}$

c) $V_{IH} = 1.4 - .5 = \boxed{.9V}$

d) $I_{B1} = \frac{5-1.4}{2k} = 1.8$

$I_{IL} = B_F I_{B1} = \boxed{.18mA}$

f) $I_{B2B} = -.7/1k = \boxed{-.7mA}$

g) $I_{B2(EOS)} = \frac{24mA}{30}$

$I_{C(SAT)} = V_{CC} - V_{CE(SAT)} / RC = 4.8/200 = .024A = 24mA$

e) $I_{C1} * t_{R21} = t_{B2F}$

$I_{C1} = (\beta_{FH}) I_{B1} = (1.1)(1.8) = 1.98 - .7 = \boxed{1.28mA}$

h)

$T_S = 10ns \cdot \ln\left[\frac{.7 - 1.25}{.7 - .5}\right]$

$= \boxed{2.77ns}$

i) $t_r = 2.2T$
$2.2 R_C C = 4.4ns$

$t_f = 100pF \cdot .7V / 35mA = \boxed{1.514ns}$

2) TTL NAND GATE

a) $V_{B1} = .2 + .3 + .7 = 1.2V$

$$I_{IL} = \frac{5 - 1.2}{4k} = \frac{3.8}{4k} = .95mA = \boxed{.475mA}$$

b) $\boxed{I_H = 0A}$

c) $I_{o_{MIN}} = B_F I_{B4} = 51.75mA$

d) $I_{B3} = \frac{5 - (3 + 1.4)}{1600} = .375mA$

$$I_{C3} = \frac{5 - (3.9)}{200} = 5.5mA$$

$(.375 + 5.5)mA = \boxed{5.875mA}$

e)

$$N_{LOL} = 51.75mA / .5mA = \boxed{54}$$

f) $N = 5.875/0 = \boxed{\infty}$

h) $t_r = \frac{C \Delta V}{I_o} = 10pF \cdot \frac{2.4V}{7.564 5mA} = \boxed{1.658ns}$

4) DLT GATE

a) $V_{IL} = .5 + .7 = \boxed{1.2V}$

b)

$I_{C(SAT)} = 5mA$

$I_{B(EOS)} = \frac{5mA}{20} = .25mA$

$V_{IH} = 1.4 + (.25)(10k) = \boxed{3.9V}$

c) $I_{C(SAT)} = 5mA + 10mA = 15mA$

$I_{B(EOS)} = 15/20 = .75mA$

$V_{IH} = 1.4 + (.75/2)(10k) = \boxed{5.15V}$

d)

$\boxed{N = \infty}$

e) $V_{IH} = 3.9V \quad \frac{5 - 3.9}{1000} = 1.1mA$

$N = \frac{1.1mA}{.25mA} = \boxed{4}$

5) TTL GATE

a) $V_{IL} = V_{C1} - V_{CE(SAT)} = 1 - .2 = \boxed{.8V}$

b) $V_{B1} = .3 + .7 = \boxed{1V}$

↳ $I_{B1} = 4/10k = .4mA$

$I_{IL} = (1+1) \cdot .4mA = \boxed{.8mA}$

c) $I_{E3} = 5mA = I_{B3} + I_{C3}$

$= \frac{(5 - 1.4 - V_o)}{1000} + \frac{(5 - .9 - V_o)}{100}$

$11V_o = 39.6 \quad \therefore \quad \boxed{V_o = 3.6V}$

d) $V_{B1} = 2.1V; \quad I_{B1} = \frac{5 - 2.1}{10k} = .29mA$

$I_E = I_{B2} : (B_R+1)(.27mA) = .435mA$

$V_{C2} = .7 + .2 = .9$

$I_{C2} = \frac{4.1}{1K} = 4.1mA$

$I_O = B_r \cdot I_{B4} = 20.4535 = \boxed{90.7mA}$

e) $N = \frac{90.7}{.55}\frac{mA}{mA} = \boxed{113}$

6) TTL GATE

a) current would be **zero**

b)

$V_{B3} = 1.4 \rightarrow I_{B3} = 2.57mA$

$V_{C3} = .7 + .2 + 0 = .9V$

$I_{C3} = 4.1mA$

$I_{E3} = 2.57 + 4.1 = \boxed{43.67mA}$

7) FAN OUT

a) $V_i(max) = .7 + .7 - .3 = \boxed{1.1V}$

b) $V_{B1} = 3(.7) = 2.1V$

$I_{RB1} = \frac{5-2.1}{4K} = .725mA$

$I'_C = .5(.725) = \boxed{.3625mA}$

$I''_E = 1.5(.725) = 1.0875$

$I_{RB2} = .7/1.2K = \boxed{.583mA}$

c) $I_{RC2} = \frac{3.9}{1.2} = 3.25mA$

$I_{C2} = 12.6mA$

$I_O = 12.6 - 3.25 = 9.35mA$

$N = \frac{9.35}{.8} = \boxed{11}$

d) $I_{RC2} = \frac{2}{1.2} = 1.667\text{mA} = I_o$

$I_{IH} = I_E = I_{"L"} = .362\text{mA}$

$N = \frac{1.667}{.362} = \boxed{4}$

8) DTL GATE:

a) $V_{IL} = .5 - .2 - .2$

$= \boxed{.1V}$

b) $I_{B1} = \frac{4.1}{2K} = 2.05\text{mA}$; $V_{B1} = .9$

$V_{C1} = .2 + .2 = .4V$

$I_{C1} = \frac{4.6}{4K} = 1.15\text{mA}$

$I_{IL} = 2.05 + 1.15 = \boxed{3.2\text{mA}}$

c) $V_{IH} = .7 + .7 - .5 - .2 = \boxed{.7V}$

d)

$I_{IH} = 0$

e) $I_{B1} = \frac{5 - 1.4}{2K} = 1.8\text{mA} = I_{"E"}$

$I_{RB2} = \frac{5 - .7}{4K} = 1.075\text{mA}$

$I_{B2} = \boxed{2.875\text{mA}}$

f)

$V_{B1} = 1V \rightarrow I_{B1} = \frac{4}{2K} = 2\text{mA}$, $I_{C1} = \beta I_B$

$= 10(2\text{mA})$

$= 20\text{mA}$

$I_{B2R} = 20 - \frac{(5 - .7)}{4K} = \boxed{18.93\text{mA}}$

9) TTL GATE:

a) $V_{IL} = .5V + .5V - .2V$
$= .8V$

b) $V_{B1} = V_{B4} + V_{BE2} + V_{BE}$ = 2.1

$V_{IH} = 2.1 - .5 = \boxed{1.6V}$

c) $Q_1 \rightarrow$ Reversed
$Q_2 \rightarrow$ saturated
$Q_4 \rightarrow$ saturated
$Q_5 \rightarrow$ off

d) $I_o = 0$

e) $Q_1 \rightarrow$ saturated
Q_2 & $Q_4 \rightarrow$ off
$Q_3 \rightarrow$ saturated

f) $V_{B3} = 2(.7) = 1.4$; $I_{B3} = \frac{3.6}{1.4} = 2.57mA$
$V_{C3} = .7 + .2 = .9$; $I_{C3} = \frac{4.1}{100} = 41mA$

$I_o = 41 + 2.57 = \boxed{43.57mA}$