

Thermal Conductivity

Material	Thermal conductivity (cal/sec)/(cm ² C/cm)	Thermal conductivity (W/m K)*
Diamond	...	1000
Silver	1.01	406.0
Copper	0.99	385.0
Gold	...	314
Brass	...	109.0
Aluminum	0.50	205.0
Iron	0.163	79.5
Steel	...	50.2
Lead	0.083	34.7
Mercury	...	8.3
Ice	0.005	1.6
Glass,ordinary	0.0025	0.8
Concrete	0.002	0.8
Water at 20° C	0.0014	0.6
Asbestos	0.0004	0.08
Snow (dry)	0.00026	...
Fiberglass	0.00015	0.04
Brick,insulating	...	0.15
Brick, red	...	0.6
Cork board	0.00011	0.04
Wool felt	0.0001	0.04
Rock wool	...	0.04
Polystyrene (styrofoam)	...	0.033
Polyurethane	...	0.02
Wood	0.0001	0.29
Air at 0° C	0.000057	0.024
Helium (20°C)	...	0.138

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Reference
[Young](#)
Ch 15.

Hydrogen(20°C)	...	0.172
Nitrogen(20°C)	...	0.0234
Oxygen(20°C)	...	0.0238
Silica aerogel	...	0.003

*Most from Young, Hugh D., University Physics, 7th Ed. Table 15-5. Values for diamond and silica aerogel from CRC Handbook of Chemistry and Physics.

Note that $1 \text{ (cal/sec)/(cm}^2 \text{ C/cm)} = 419 \text{ W/m K}$. With this in mind, the two columns above are not always consistent. All values are from published tables, but can't be taken as authoritative.

The value of 0.02 W/mK for polyurethane can be taken as a nominal figure which establishes polyurethane foam as one of the best insulators. NIST published a numerical approximation routine for calculating the thermal conductivity of polyurethane at <http://cryogenics.nist.gov/NewFiles/Polyurethane.html> . Their calculation for freon filled polyurethane of density 1.99 lb/ft³ at 20°C gives a thermal conductivity of 0.022 W/mK. The calculation for CO₂ filled polyurethane of density 2.00 lb/ft³ gives 0.035 W/mK .

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Wiedemann-Franz Ratio

The ratio between thermal and electrical conductivities of metals can be expressed in terms of the ratio:

$$L = \frac{\kappa}{\sigma T} = \frac{\pi^2 k^2}{3e^2} = 2.45 \times 10^{-8} \text{ W}\Omega/\text{K}^2$$

which may be called the Wiedemann-Franz Ratio or the Lorenz constant.

Metal	$\kappa/\sigma T$ ($10^{-8} \text{ W}\Omega/\text{K}^2$)
Cu	2.23
Ag	2.31
Au	2.35
Zn	2.31
Cd	2.42
Sn	2.52
Mo	2.61
Pb	2.47
Pt	2.51

[Heat conduction discussion](#)

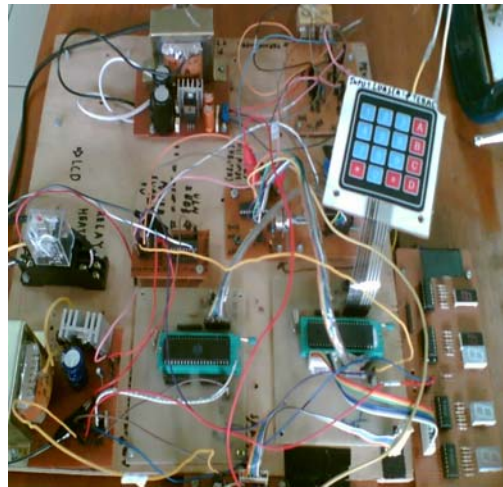
[Wiedemann-Franz Law](#)

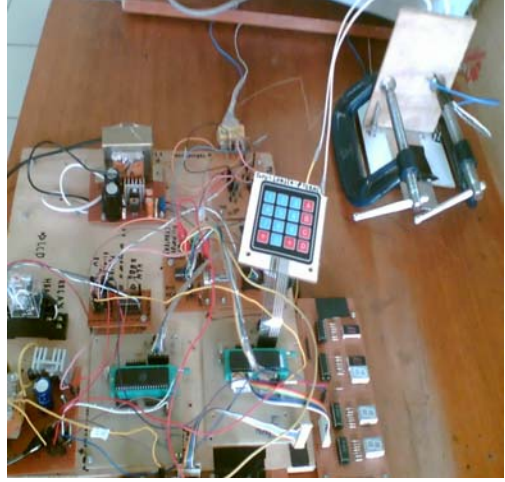
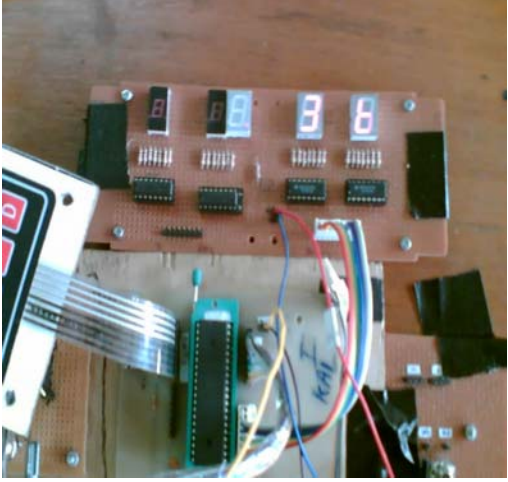
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Foto Alat





Program pada MCS-51 II : Kontrol Heater

\$MOD51

MOV P2,#01h

; Mula-mula *heater on*, lalu masukkan *set point* dengan tekan tombol 6 (150°C) atau B (250°C) dalam waktu beberapa detik agar suhu heater tidak melewati *set point*.

```
SCAN1:    MOV A,P3
           CJNE A,#01H, CEK_250
           MOV A,#85H
           AJMP S_150

CEK_250:   CJNE A,#02H, SCAN1
           MOV A,#0FEH
           AJMP S_250

S_150:     MOV P1,A
           CJNE A,#085H, NYALA1
           MOV A,#00H
           MOV P2,A
           AJMP S_150

NYALA1:    CJNE A,#79H,S_150
           MOV A,#01H
           MOV P2,A
           AJMP S_150

S_250:     MOV P1,A
           CJNE A,#0FEH, NYALA2
           MOV A,#00H
           MOV P2,A
           AJMP S_250

NYALA2:    CJNE A,#0F2H,S_250
           MOV A,#01H
           MOV P2,A
           AJMP S_250
```

END

Program pada MCS-51 I : Kalkulasi dan tampilkan output

```
$MOD51  
MOV P2,#00H
```

```
;Input set point
```

```
SP:   MOV P1,#10111111b  
      JB P1.1,S_250  
      MOV A,#01H  
      MOV R4,A  
      AJMP OUT3
```

```
S_250: JB P1.1,SP  
      MOV A,#02H  
      MOV R4,A  
      AJMP OUT3
```

```
OUT3:  MOV P3,A  
TES:   CJNE R4,#01H, C250  
      AJMP C250
```

```
250N:  CJNE R4,#02H, TES  
      AJMP C150
```

```
;input keypad dulu u/ D
```

```
C150:  
scan_AA:  MOV P1,#01111111b  
          JB P1.2,TIGA  
          MOV A,#02H  
          MOV R0,A  
          AJMP cek
```

```
TIGA_AA:  JB P1.1,EMPAT  
          MOV A,#03h  
          MOV R0,A  
          AJMP cek
```

```
EMPAT_AA:  
          MOV P1,#10111111b  
          JB P1.3,LIMA  
          MOV A,#04H  
          MOV R0,A  
          AJMP cek
```

```
LIMA:     JB P1.2,scan  
          MOV A,#05h  
          MOV R0,A  
          AJMP cek
```

```
cek_AA:   MOV P1,#01111111b  
          JB P1.0,cek_AA  
          ACALL DELAY_12S  
          MOV A,P0  
          AJMP D2a
```

;Deteksi hasil

D2a: CJNE R0,#02H,D3a
AJMP CEK_A
D3a: CJNE R0,#03H,D4a
AJMP CEK_B
D4a: CJNE R0,#04H,D5a
AJMP CEK_C
D5a: CJNE R0,#05H, scan_AA
AJMP CEK_D

CEK_A: CJNE A,#2DH,S46A
MOV A,# 38H
AJMP OUT1
S46A: CJNE A,#2EH,S47A
MOV A,# 38H
AJMP OUT1
S47A: CJNE A,#2FH,S48A
MOV A,# 39H
AJMP OUT1
S48A: CJNE A,#30H,S49A
MOV A,# 39H
AJMP OUT1
S49A: CJNE A,#31H,S50A
MOV A,# 40H
AJMP OUT1
S50A: CJNE A,#32H,S51A
MOV A,# 40H
AJMP OUT1
S51A: CJNE A,#33H,S52A
MOV A,# 40H
AJMP OUT1
S52A: CJNE A,#34H,S53A
MOV A,# 41H
AJMP OUT1
S53A: CJNE A,#35H,S54A
MOV A,# 41H
AJMP OUT1
S54A: CJNE A,#36H,S55A
MOV A,#42H
AJMP OUT1
S55A: CJNE A,#37H,S56A
MOV A,#42H
AJMP OUT1
S56A: CJNE A,#38H,S57A
MOV A,# 43H
AJMP OUT1
S57A: CJNE A,#39H,S58A
MOV A,# 43H
AJMP OUT1
S58A: CJNE A,#3AH,S59A
MOV A,# 43H
AJMP OUT1
S59A: CJNE A,#3BH,S60A
MOV A,# 44H


```
    AJMP OUT1
S60A: CJNE A,#3CH,CEK_A
      MOV A,#44H
      AJMP OUT1

CEK_B: CJNE A,#23H,S36B
      MOV A,#53H
      AJMP OUT1
S36B: CJNE A,#24H,S37B
      MOV A,#53H
      AJMP OUT1
S37B: CJNE A,#25H,S38B
      MOV A,#54H
      AJMP OUT1
S38B: CJNE A,#26H,S39B
      MOV A,#54H
      AJMP OUT1
S39B: CJNE A,#27H,S40B
      MOV A,#54H
      AJMP OUT1
S40B: CJNE A,#28H,S41B
      MOV A,#55H
      AJMP OUT1
S41B: CJNE A,#29H,S42B
      MOV A,#55H
      AJMP OUT1
S42B: CJNE A,#2AH,S43B
      MOV A,#56H
      AJMP OUT1
S43B: CJNE A,#2BH,S44B
      MOV A,#56H
      AJMP OUT1
S44B: CJNE A,#2CH,S45B
      MOV A,#57H
      AJMP OUT1
S45B: CJNE A,#2DH,S46B
      MOV A,#57H
      AJMP OUT1
S46B: CJNE A,#2EH,S47B
      MOV A,#58H
      AJMP OUT1
S47B: CJNE A,#2FH,S48B
      MOV A,#58H
      AJMP OUT1
S48B: CJNE A,#30H,S49B
      MOV A,#59H
      AJMP OUT1
S49B: CJNE A,#31H,S50B
      MOV A,#59H
      AJMP OUT1
S50B: CJNE A,#32H,S51B
      MOV A,#60H
      AJMP OUT1
S51B: CJNE A,#33H,S52B
      MOV A,#61H
      AJMP OUT1
```

```
S52B:  CJNE A,#34H,S53B
        MOV A,#61H
        AJMP OUT1
S53B:  CJNE A,#35H,S54B
        MOV A,#62H
        AJMP OUT1
S54B:  CJNE A,#36H,S55B
        MOV A,#63H
        AJMP OUT1
S55B:  CJNE A,#37H,CEK_B
        MOV A,#63H
        AJMP OUT1

CEK_C: CJNE A,#23H,S36C
        MOV A,#53H
        AJMP OUT1
S36C:  CJNE A,#24H,S37C
        MOV A,#53H
        AJMP OUT1
S37C:  CJNE A,#25H,S38C
        MOV A,#54H
        AJMP OUT1
S38C:  CJNE A,#26H,S39C
        MOV A,#54H
        AJMP OUT1
S39C:  CJNE A,#27H,S40C
        MOV A,#55H
        AJMP OUT1
S40C:  CJNE A,#28H,S41C
        MOV A,#55H
        AJMP OUT1
S41C:  CJNE A,#29H,S42C
        MOV A,#55H
        AJMP OUT1
S42C:  CJNE A,#2AH,S43C
        MOV A,#56H
        AJMP OUT1
S43C:  CJNE A,#2BH,S44C
        MOV A,#56H
        AJMP OUT1
S44C:  CJNE A,#2CH,S45C
        MOV A,#57H
        AJMP OUT1
S45C:  CJNE A,#2DH,CEK_C
        MOV A,#57H
        AJMP OUT1

CEK_D: CJNE A,#1EH,S31C
        MOV A,#86H
        AJMP OUT1
S31D:  CJNE A,#1FH,S32D
        MOV A,#86H
        AJMP OUT2
S32D:  CJNE A,#20H,S33D
        MOV A,#86H
        AJMP OUT2
```

```

S33D: CJNE A,#21H,S34D
      MOV A,#87H
      AJMP OUT1
S34D: CJNE A,#22H,S35D
      MOV A,#87H
      AJMP OUT1
S35D: CJNE A,#23H,S36D
      MOV A,#88H
      AJMP OUT1
S36D: CJNE A,#24H,S37D
      MOV A,#88H
      AJMP OUT1
S37D: CJNE A,#25H,S38C
      MOV A,#89H
      AJMP OUT1
S38D: CJNE A,#26H,S39D
      MOV A,#89H
      AJMP OUT1
S39C: CJNE A,#27H,S40D
      MOV A,#90H
      AJMP OUT1
S40D: CJNE A,#28H, S41D
      MOV A,#91H
      AJMP OUT1
S41D: CJNE A,#29H,S42D
      MOV A,#92H
      AJMP OUT2
S42D: CJNE A,#2AH,S43D
      MOV A,#93H
      AJMP OUT1
S43D: CJNE A,#2B1H,S44D
      MOV A,#93H
      AJMP OUT1
S44D: CJNE A,#2CH,S45D
      MOV A,#94H
      AJMP OUT1
S45D: CJNE A,#2DH, CEK_D
      MOV A,#95H
      AJMP OUT1

```

;Input D melalui keypad

C250:

```

scan_BB:    MOV P1,#01111111b
            JB P1.2,TIGA
            MOV A,#02H
            MOV R0,A
            AJMP cek

```

```

TIGA_BB:    JB P1.1,EMPAT
            MOV A,#03h
            MOV R0,A
            AJMP cek

```

```

EMPAT_BB:   MOV P1,#10111111b
            JB P1.3,LIMA
            MOV A,#04H

```

```

MOV R0,A
AJMP cek

LIMA_BB:  JB P1.2,scan
           MOV A,#05h
           MOV R0,A
           AJMP cek

cek_B:    MOV P1,#01111111b ; tekan tombol A
           JB P1.0,cek_B
           ACALL DELAY_12S
           MOV A,P0
           AJMP D2

```

;Deteksi hasil

```

D2:  CJNE R0,#02H,D3
      AJMP CEK_Ab
D3:  CJNE R0,#03H,D4
      AJMP CEK_Bb
D4:  CJNE R0,#04H,D5
      AJMP CEK_Cb
D5:  CJNE R0,#05H,scan_BB
      AJMP CEK_Db

CEK_Ab: CJNE A,#3CH,S61Ab
        MOV A,#21H
        AJMP OUT1
S61Ab:  CJNE A,#3DH,S62Ab
        MOV A,#21H
        AJMP OUT1
S62Ab:  CJNE A,#3EH,S63Ab
        MOV A,#21H
        AJMP OUT1
S63Ab:  CJNE A,#3FH,S64Ab
        MOV A,#21H
        AJMP OUT1
S64Ab:  CJNE A,#40H,S65Ab
        MOV A,#22H
        AJMP OUT1
S65Ab:  CJNE A,#41H,S66Ab
        MOV A,#22H
        AJMP OUT1
S66Ab:  CJNE A,#42H,S67Ab
        MOV A,#22H
        AJMP OUT1
S67Ab:  CJNE A,#43H,S68Ab
        MOV A,#22H
        AJMP OUT1
S68Ab:  CJNE A,#44H,S69Ab
        MOV A,#22H
        AJMP OUT1
S69Ab:  CJNE A,#45H,S70Ab
        MOV A,#22H
        AJMP OUT1
S70Ab:  CJNE A,#46H,S71Ab
        MOV A,#22H

```

```
    AJMP OUT1
S71Ab: CJNE A,#47H,S72Ab
        MOV A,#22H
        AJMP OUT1
S72Ab: CJNE A,#48H,S73Ab
        MOV A,#22H
        AJMP OUT1
S73Ab: CJNE A,#49H,S74Ab
        MOV A,#23H
        AJMP OUT1
S74Ab: CJNE A,#4AH,S75Ab
        MOV A,#23H
        AJMP OUT1
S75Ab: CJNE A,#4BH,CEK_Ab
        MOV A,#23H
        AJMP OUT1
```

```
CEK_Bb: CJNE A,#32H,S51Bb
        MOV A,#30H
        AJMP OUT1
S51Bb:  CJNE A,#33H,S52Bb
        MOV A,#30H
        AJMP OUT1
S52Bb:  CJNE A,#34H,S53Bb
        MOV A,#30H
        AJMP OUT1
S53Bb:  CJNE A,#35H,S54Bb
        MOV A,#30H
        AJMP OUT1
S54Bb:  CJNE A,#36H,S55Bb
        MOV A,#31H
        AJMP OUT1
S55Bb:  CJNE A,#37H,S56Bb
        MOV A,#31H
        AJMP OUT1
S56Bb:  CJNE A,#38H,S57Bb
        MOV A,#31H
        AJMP OUT1
S57Bb:  CJNE A,#39H,S58Bb
        MOV A,#31H
        AJMP OUT1
S58Bb:  CJNE A,#3AH,S59Bb
        MOV A,#31H
        AJMP OUT1
S59Bb:  CJNE A,#3BH,S60B
        MOV A,#31H
        AJMP OUT1
S60Bb:  CJNE A,#3CH,S61Bb
        MOV A,#31H
        AJMP OUT1
S61Bb:  CJNE A,#33H,S62Bb
        MOV A,#32H
        AJMP OUT1
S62Bb:  CJNE A,#34H,S63Bb
        MOV A,#32H
        AJMP OUT1
```

S63Bb: CJNE A,#35H,S64Bb
MOV A,#32H
AJMP OUT1
S64Bb: CJNE A,#36H,S65Bb
MOV A,#32H
AJMP OUT1
S65Bb: CJNE A,#37H,CEK_Bb
MOV A,#32H
AJMP OUT1

CEK_Cb: CJNE A,#28H,S41Cb
MOV A,#38H
AJMP OUT1
S41Cb: CJNE A,#29H,S42Cb
MOV A,#38H
AJMP OUT1
S42Cb: CJNE A,#2AH,S43Cb
MOV A,#38H
AJMP OUT1
S43Cb: CJNE A,#2BH,S44Cb
MOV A,#399H
AJMP OUT1
S44Cb: CJNE A,#2CH,S45Cb
MOV A,#39H
AJMP OUT1
S45Cb: CJNE A,#2DH,S46Cb
MOV A,#39H
AJMP OUT1
S46Cb: CJNE A,#2EH,S47Cb
MOV A,#39H
AJMP OUT1
S47Cb: CJNE A,#2FH,S48Cb
MOV A,#40H
AJMP OUT1
S48Cb: CJNE A,#30H,S49Cb
MOV A,#40H
AJMP OUT1
S49Cb: CJNE A,#31H,S50Cb
MOV A,#40H
AJMP OUT1
S50Cb: CJNE A,#32H,S51Cb
MOV A,#40H
AJMP OUT1
S51Cb: CJNE A,#33H,S52Cb
MOV A,#40H
AJMP OUT1
S52Cb: CJNE A,#34H,S53Cb
MOV A,#40H
AJMP OUT1
S53Cb: CJNE A,#35H,S54Cb
MOV A,#41H
AJMP OUT1
S54Cb: CJNE A,#36H,S55Cb
MOV A,#41H
AJMP OUT1
S55Cb: CJNE A,#37H,CEK_Cb

```

MOV A,#41H
AJMP OUT1

CEK_Db: CJNE A,#23H,S36D
MOV A,#46H
AJMP OUT2
S36Db: CJNE A,#24H,S37Db
MOV A,#46H
AJMP OUT2
S37Db: CJNE A,#25H,S38Db
MOV A,#47H
AJMP OUT2
S38Db: CJNE A,#26H,S39Db
MOV A,#47H
AJMP OUT2
S39Db: CJNE A,#27H,S40Db
MOV A,#47H
AJMP OUT2
S40Db: CJNE A,#28H,S41Db
MOV A,#48H
AJMP OUT2
S41Db: CJNE A,#29H,S42Db
MOV A,#48H
AJMP OUT1
S42Db: CJNE A,#2AH,S43Db
MOV A,#48H
AJMP OUT1
S43Db: CJNE A,#2BH,S44Db
MOV A,#48H
AJMP OUT1
S44Db: CJNE A,#2CH,S45Db
MOV A,#49H
AJMP OUT1
S45Db: CJNE A,#2DH,CEK_Db
MOV A,#49H
AJMP OUT1

OUT1: MOV P2,#00H           ;out ke 7segment
      ACALL DELAY_2S:
      MOV P2,A
      AJMP scan

OUT2: MOV P2,#01H           ;out ke 7segment
      ACALL DELAY_2S
      MOV P2,A
      AJMP scan

DELAY_2S:  MOV R5,#00H
ulang0:    MOV R7,#00H
ULANG2:    MOV R6,#00H
ULANG1:    INC R6
           CJNE R6,#0FFH,ULANG1

```

```
INC R7
CJNE R7,#0FFH,ULANG2
INC R5
CJNE R5,#04h,ulang0
RET
```

```
DELAY_12S: MOV R1,#00H
ULANG4:    MOV R2,#00H
ULANG5:    MOV R3,#00H
ULANG6:    INC R3
           CJNE R3,#0FFH,ULANG6
           INC R2
           CJNE R2,#0FFH,ULANG5
           INC R1
           CJNE R1,#35h,ULANG4
           RET
```

```
END
```