

Q1 pg-1

classmate

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Tutorial-6

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①

$$i = m - 1$$

$$j = n$$

$$t_1 = 4 * m$$

$$P = a[t_1]$$

↓

$$i = i + 1$$

$$t_2 = 4 * i$$

$$t_3 = a[t_2]$$

if $t_3 > P$ goto B₂

$$t_{11} = 4 * i$$

$$t = a[t_{11}]$$

$$t_{12} = 4 * i$$

$$t_{13} = 4 * m$$

$$t_{14} = a[t_{13}]$$

$$a[t_{12}] = t_{14}$$

$$t_{15} = 4 * n$$

$$a[t_{15}] = t$$

$$j = j - 1$$

$$t_{16} = 4 * j$$

$$t_5 = a[t_4]$$

if $t_5 > P$ goto B₃

if $i \geq j$ goto B₆

B₁

↓
B₂

B₃

B₅

B₄

B₆

Replacing goto with block nos.

$$t_6 = 4 * i$$

$$t = a[t_6]$$

$$t_7 = 4 * i$$

$$t_8 = 4 * j$$

$$t_9 = a[t_8]$$

$$a[t_7] = t_9$$

$$t_{10} = 4 * j$$

$$a[t_{10}] = t$$

goto B₂

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local common subexpression elimination

B5 B6

B5

$$\begin{array}{l} t_6 = u * i \\ \hline t = q [t_6] \end{array}$$

$$t_7 = t_6$$

$$t_8 = u * j$$

$$t_9 = q [t_8]$$

$$q [t_7] = t_9$$

$$t_{10} = t_8$$

$$q [t_{10}] = t$$

goto B2

B6

$$t_{11} = u * i$$

$$t = q [t_{11}]$$

$$t_{12} = t_{11}$$

$$t_{13} = u * n$$

$$t_{14} = q [t_{13}]$$

$$q [t_{12}] = t_{14}$$

$$t_{15} = t_{13}$$

$$q [t_{15}] = t$$

copy propagation for $t_7, t_{10}, t_{12}, t_{15}$

$$t_6 = u * i$$

$$t = q [t_6]$$

$$t_7 = t_6$$

$$t_8 = u * j$$

$$t_9 = q [t_8]$$

$$q [t_6] = t_9$$

$$t_{10} = t_8$$

$$q [t_8] = t$$

goto B2

$$t_{11} = u * i$$

$$t = q [t_{11}]$$

$$t_{12} = t_{11}$$

$$t_{13} = u * n$$

$$t_{14} = q [t_{13}]$$

$$q [t_{11}] = t_{14}$$

$$t_{15} = t_{13}$$

$$q [t_{15}] = t$$

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Dead code elimination for $t_7 + t_{10} + t_2 + t_5$

$$t_6 = 4 * i$$

$$t_7 = a[t_6]$$

$$t_8 = 11 * j$$

$$t_9 = a[t_8]$$

$$a[t_6] = t_9$$

$$a[t_8] = t$$

goto B2

$$t_{11} = 4 * i$$

$$t = a[t_{11}]$$

$$t_{14} = a[t_{13}]$$

$$a[t_{11}] = t_{14}$$

$$a[t_{13}] = t$$

Global common subexpression elimination.

$i = m - 1$
$j = n$
$t_1 = u \& n$
$\overbrace{P = a[t_1]}$

$t_6 = t_2$
$t = a[t_6]$
$t_8 = t_4$
$t_9 = a[t_8]$
$a[t_6] = t_9$
$a[t_8] = t$
goto B2

$i = i + 1$
$t_2 = u * i$
$t_3 = a[t_2]$
$\text{if } t_3 < P \text{ goto B2}$

$j = j - 1$
$t_4 = u * j$
$t_5 = a[t_4]$
$\text{if } t_5 > P \text{ goto B2}$

$t_{11} = t_2$
$t = a[t_{11}]$
$t_{13} = t_1$
$t_{14} = a[t_{13}]$
$a[t_{11}] = t_{14}$
$a[t_{13}] = t$

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copy propagation on t_6, t_8, t_{11}, t_{13}

$$t_6 = t_2$$

$$t = q[t_2]$$

$$t_8 = t_4$$

$$q[t_2] = t_8$$

$$q[t_2] = t_8$$

$$q[t_4] = t_8$$

goto B₁

$$t_{12} = t_2$$

$$t = q[t_1]$$

$$t_{13} = t_1$$

$$q[t_1] = t_{13}$$

$$q[t_1] = t_{13}$$

$$q[t_1] = t$$

dead code elimination on t_6, t_8, t_{11}, t_{13}

B₅

$$t = q[t_2]$$

$$t_9 = q[t_8]$$

$$q[t_2] = t_9$$

$$q[t_8] = t$$

goto B₂

B₆

$$t = q[t_2]$$

$$t_{10} = q[t_3]$$

$$q[t_2] = t_{10}$$

$$q[t_3] = t$$

Global common sub expression elim

i = m + 1
j = n
t ₁ = u * n
p = q[t ₁]

i = p + 1
t ₂ = u * i
t ₃ = q[t ₂]
if t ₃ < p goto B ₂

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t = t ₃
t ₄ = t ₅
q[t ₂] = t ₉
q[t ₄] = t
goto B ₂

j' = j - 1
t ₄ = u * j'
t ₅ = q[t ₄]
if t ₅ > p goto B ₂

i & j' goto B ₁

t = t ₃
t ₄ = p
q[t ₂] = t ₄
q[t ₁] = t

copy propagation on t, t_1, t_2

B5

$t = t_3$

$t_1 = t_5$

$a[t_2] = t_5$

$a[t_4] = t_3$

goto B6

B5

$t = t_3$

$t_1 = p$

$a[t_2] = p$

$a[t_4] = t_3$

dead code elimination on t, t_1, t_2

B5

$a[t_2] = t_5$

$a[t_4] = t_3$

goto B2

B5

$a[t_2] = p$

$a[t_4] = t_3$

strength reduction,

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$i = m + 1$

$j = n$

$t = 4 * n$

$p = a[t_1]$

$t_2 = u * j$

$t_4 = u * j$

$i = i + 1$

$t_2 = t_2 + 4$

$t_3 = a[t_2]$ S

if $t_3 < p$ goto B2

$j = j - 1$

$t_4 = t_4 - 4$

$t_5 = a[t_4]$ S

if $t_5 > p$ goto B2

$$\begin{cases} a[t_2] = p \\ a[t_4] = t_3 \end{cases}$$

$$\begin{cases} a[t_2] = t_5 \\ a[t_4] = t_3 \end{cases}$$

$$\begin{cases} a[t_2] = t_5 \\ a[t_4] = t_3 \end{cases}$$

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$$\begin{cases} a[t_2] = t_5 \\ a[t_4] = t_3 \end{cases}$$

$$\begin{cases} a[t_2] = t_5 \\ a[t_4] = t_3 \end{cases}$$

Induction variables

B1

$$i = m - 1$$

$$j = n$$

$$t_4 = i * n$$

$$t_4 = a + i$$

$$t_2 = u * i$$

$$u_2 = a + t_2$$

$$u_4 = u_1$$

$$P = [u_4, j]$$

B2

Q.

$$i = i + 1$$

$$u_2 = u_2 + u$$

$$t_3 = [u_2]$$

if $t_3 < P$ goto B2

B3

$$j = j - 1$$

$$u_4 = u_4 - u_1$$

$$t_5 = [u_4]$$

if $t_5 > P$ goto B3

B4

$$[u_2] = t_5$$

$$[u_4] = t_3$$

goto B9

if $i > j$ goto B4

B6

$$[u_2] = P$$

$$[u_4] = t_3$$

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Question - 2

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Code 2

- (2) $i = 1$
- 1) $j = 1$
- 2) $t_1 = 10 * i$
- 3) $t_2 = t_1 + j$
- 4) $t_3 = 8 * t_2$
- 5) $t_4 = t_3 - 8$
- 6) $j = j + 1$
- 7) $i = i + 1$
- 8) $i \text{ if } j <= 10 \text{ goto (3)}$
- 9) $i = i + 1$
- 10) $i \text{ if } i <= 10 \text{ goto (2)}$
- 11) $i = 1$
- 12) $t_5 = i - 1$
- 13) $t_6 = 88 * t_5$
- 14) $t_7 = t_6 - 1.0$
- 15) $i = i + 1$
- 16) $i = i + 1$
- 17) $i \text{ if } i <= 10 \text{ goto (13)}$

B1
 $i = 1$

B2
 $j = 1$

B3
 $t_1 = 10 * i$
 $t_2 = t_1 + j$
 $t_3 = 8 * t_2$
 $t_4 = t_3 - 8$
 $q[t_4] = 0.0$
 $j = j + 1$
 $i \text{ if } j <= p \text{ goto B}_3$

B4

$i = i + 1$
 $i \text{ if } i < 10 \text{ goto B}_2$

B5

$i = 1$

$t_5 = i - 1$
 $t_6 = 88 * t_5$
 $0[i[t_6]] = 1.0$
 $i = i + 1$
 $i \text{ if } i <= 10 \text{ goto B}_1$

For this Problem

NO GCSE

NO copy propagation

NO loop invariants.

induction variables.

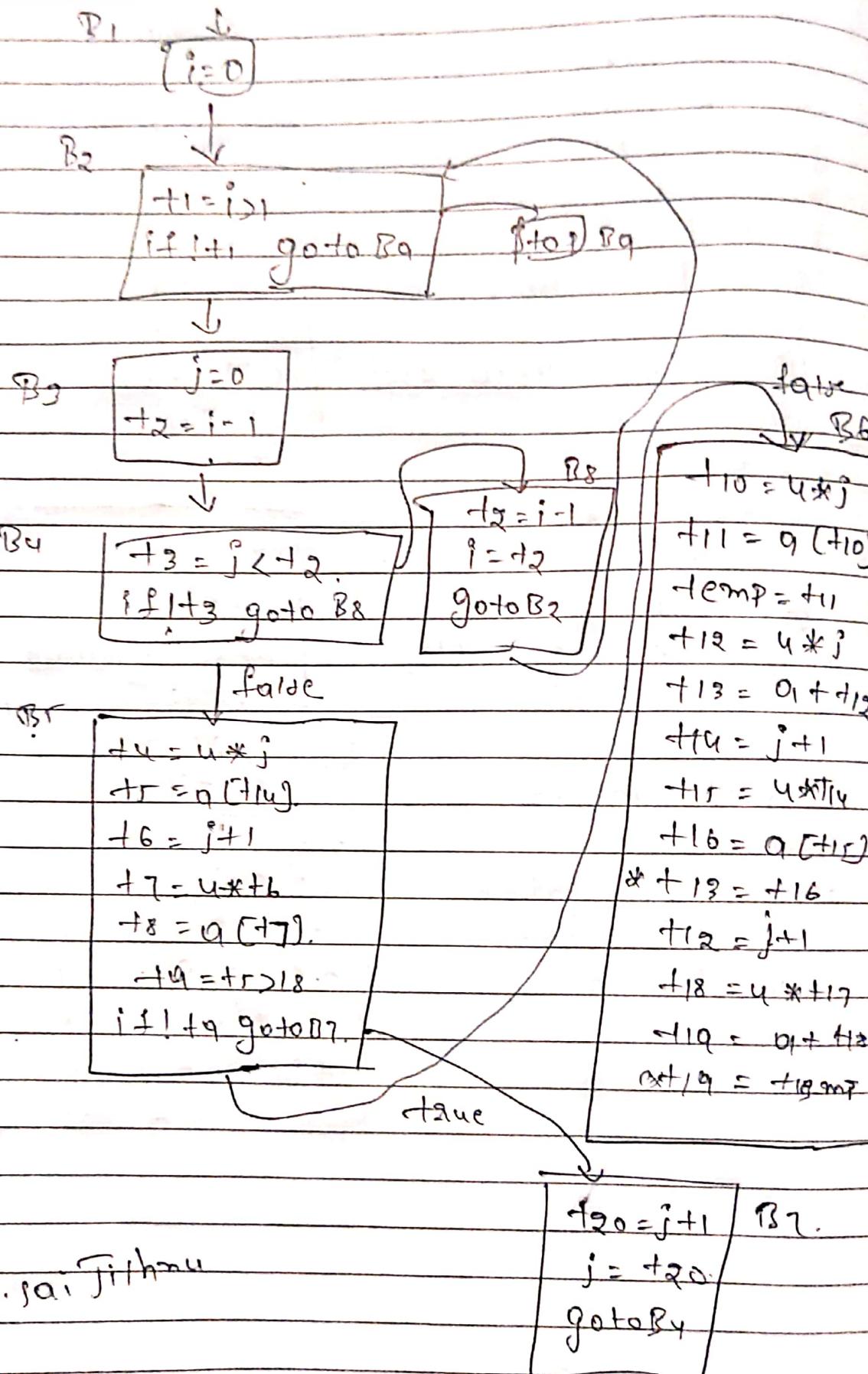
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Questions

Data
Page

③

Code 3



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GCS:

B1 [$i = 0$]B2 [$t_1 = i > 1$] $i = t_1 \text{ goto } B_9$

false

S + off B9

B3 [$t_3 \leq j < t_2$] $i = t_1 \text{ goto } B_8$

J L9 I8c

true B3

 $t_{21} = t_2$ $i = t_{21}$

goto B2

P5

 $t_{44} = 4 * j$ $t_5 = 9 [t_{44}]$ $t_6 = j + 1$ $t_7 = 4 * t_6$ $t_8 = 9 [t_7]$ $t_9 = t_5 > t_8$ $\text{if } !t_9 \text{ goto } B_7$

false

$$\begin{aligned} t_{10} &= t_4 \\ t_{11} &= a[t_{10}] \end{aligned}$$

$$\text{temp} = t_{11}$$

$$t_{12} = t_4$$

$$t_{13} = a + t_{12}$$

$$t_{14} = t_6$$

$$t_{15} = t_{14}$$

$$t_{16} = a[t_{15}]$$

$$*t_{13} = t_6$$

$$t_7 = t_6$$

$$t_{18} = 4 * t_7$$

$$t_{19} = a + t_{18}$$

$$*t_{19} = \text{temp}$$

$$t_{20} = t_6$$

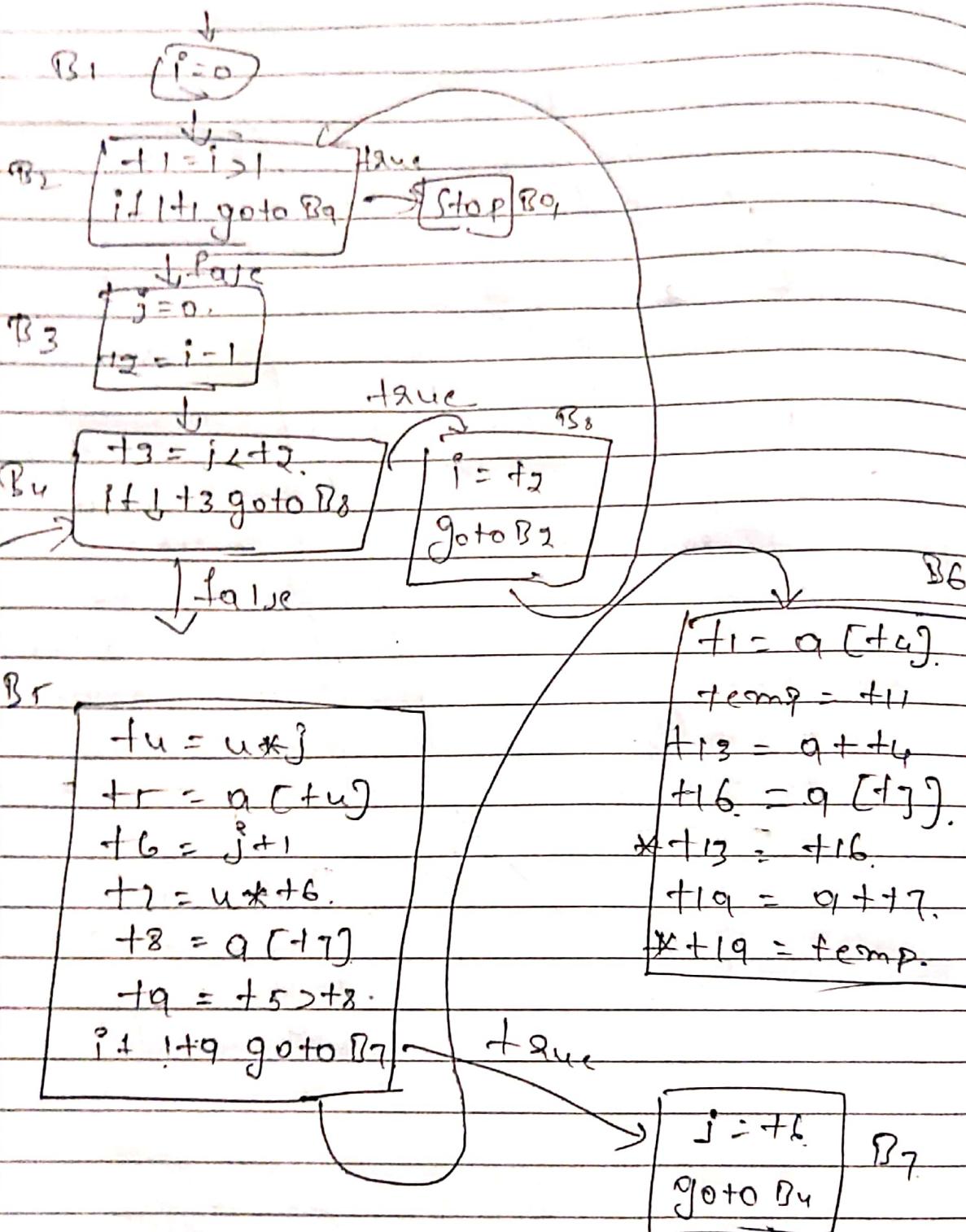
$$g = t_{20}$$

$$\text{goto } B_4$$

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GCSE and copy Propagation

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IV detection

↓

B1

 $i = 0$

B2

 $-t_1 = i \geq 1$
 if $t_1 + 1$ goto B9

down

STOP
B9

↓ -false

P0

 $j = 0$
 $s_4 = 4 \cdot k \cdot j$
 $s_6 = i + 1$
 $s_7 = 4 \cdot j$
 $s_7 = s_7 + 0$
 $t_{11} = q [+4]$ $t_{10} = t_{11}$ $t_{13} = q + t_{11}$ $t_{16} = q [+7]$ $* t_{13} = t_{16}$ $t_{19} = q + t_{17}$ $* t_{19} = temp$

↓ true B3

P1

 $t_3 = j < t_2$
 if $t_1 + t_3$ goto B8
 $t_1 = t_2$

goto B2

 $j = s_6$

P5

 $t_4 = s_4$
 $t_5 = q [+4]$
 $t_6 = s_6$
 $t_7 = s_7$
 $t_8 = q [+7]$
 $t_9 = t_5 + t_8$
 if $t_1 + t_9$ goto B7
 $s_4 = s_4 + 4$ $s_6 = s_6 + 1$ $s_7 = s_7 + 4$

goto B4

false

Final

B1 $i = j + 1$

B2

$i_1 = i_2$
if $i_1 \neq i_2$ goto B9
B9 STOP

↓ false

$j = 0, i_2 = i - 1$
 $s_4 = 4 * j$,
 $i_6 = j + 1$
 $s_7 = s_4 + 4$

true
B8.
 $i = i_2$
goto B2

 $i_{11} = a[s_4]$ $t_{temp} = i_{11}$ $i_{13} = a + s_4$ $i_{16} = a[s_7]$ $* i_{13} = i_{16}$ $i_{19} = a + s_7$ ~~$* i_0 = t_{temp}$~~

B3

B4

$s_2 = i_2 * 4$
 $i_3 = s_4 < s_2$
if i_3 goto B8

↓ false.

B5

$i_5 = a[s_4]$.
 $i_8 = a[s_7]$.
 $i_9 = i_5 + i_8$
if i_9 goto B7

true

$s_4 = r_4 + 4$,
 $s_7 = s_7 + 4$. B7,
goto B4

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