Redundancy Optimizations

- Constant Folding
- Copy Propagation
- Dead Code Elimination
- Common Subexpression Elimination

Constant Folding

```
a = 1;
b = 2;
c = a + b;
```

```
c = 3;
```

- Do constant propagation dataflow analysis
- Whenever a variable is constant, replace it with the constant value.

Copy Propagation

```
x = y;
a = x + 1;
b = x * 5;
c = 7 - x;
```

```
a = y + 1;
b = y * 5;
c = 7 - y;
```

Copy Propagation

Reaching copies dataflow analysis

1. Forwards

At each use of $\mathtt{x}$ where $\ell : \mathtt{x} = \mathtt{y}$ reaches, replace $\mathtt{x}$ with $\mathtt{y}$.

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   ℓ:`x = y` $\quad \mathrm{out}_\ell = \{\ell\} \cup (\mathrm{in}_\ell \setminus \{\texttt{x = *}, \texttt{* = x}\})$

   ℓ:`x = ...` $\quad \mathrm{out}_\ell = \mathrm{in}_\ell \setminus \{\texttt{x = *}, \texttt{* = x}\}$

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5. start node value is $\{\}$
6. $\bot = \{\text{all copies}\}$

At each use of `x` where ℓ:`x = y` reaches, replace `x` with `y`.

Dead Code Elimination

```
z = x + y;
z never used
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```
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NOTE: Watch out for side effects. (z = x/y)
NOTE: Eliminating dead code may make other code dead.
NOTE: DCE is not Unreachable Code Elimination:

```
if(false) { ...}
```

Common Subexpression Elimination

```
a = x + y;
b = x + y;
c = x + y;
```

```
t = x + y;
a = t;
b = t;
c = t;
```

NOTE: Often useful to do copy propagation afterwards.

Problems with CSE

- Syntactic substitution only:

```
a = x + y;
b = y + x;
```

```
a = x + y;
b = x;
c = b + y;
```

- Partial redundancies:

```
if() {
    a = x + y;
}
b = x + y;
```