

## Conjugate Gradient method

```
 $k = 0$  ;  $x_0 = 0$  ;  $r_0 = b$   
while  $r_k \neq 0$  do  
   $k := k + 1$   
  if  $k = 1$  do  
     $p_1 = r_0$   
  else  
     $\beta_k = \frac{r_{k-1}^T r_{k-1}}{r_{k-2}^T r_{k-2}}$   
     $p_k = r_{k-1} + \beta_k p_{k-1}$   
  end if  
   $\alpha_k = \frac{r_{k-1}^T r_{k-1}}{p_k^T A p_k}$   
   $x_k = x_{k-1} + \alpha_k p_k$   
   $r_k = r_{k-1} - \alpha_k A p_k$   
end while
```

## Preconditioned Conjugate Gradient method

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```
 $k = 0$  ;  $x_0 = 0$  ;  $r_0 = b$   
while  $r_k \neq 0$  do  
   $z_k = M^{-1}r_k$   
   $k := k + 1$   
  if  $k = 1$  do  
     $p_1 = z_0$   
  else  
     $\beta_k = \frac{r_{k-1}^T z_{k-1}}{r_{k-2}^T z_{k-2}}$   
     $p_k = z_{k-1} + \beta_k p_{k-1}$   
  end if  
   $\alpha_k = \frac{r_{k-1}^T z_{k-1}}{p_k^T A p_k}$   
   $x_k = x_{k-1} + \alpha_k p_k$   
   $r_k = r_{k-1} - \alpha_k A p_k$   
end while
```







