Conjugate Gradient (Polak–Ribière+)

input : starting point $\vec{x}_0$, tolerance E_s
output: $\vec{x}^*$, estimate of a local minimizer

$k \leftarrow 0$
$\vec{p}_0 \leftarrow -\nabla f(\vec{x}_0)$ `// first step is steepest descent`
while $\|\nabla f(\vec{x}_k)\| > E_s$ **do**
  $\alpha_k \leftarrow$ line search along $\vec{p}_k$
  $\vec{x}_{k+1} \leftarrow \vec{x}_k + \alpha_k \vec{p}_k$
  $\beta_{k+1} \leftarrow \max\left(0,\ \dfrac{\nabla f(\vec{x}_{k+1})^{\mathsf{T}}\left(\nabla f(\vec{x}_{k+1}) - \nabla f(\vec{x}_k)\right)}{\nabla f(\vec{x}_k)^{\mathsf{T}}\,\nabla f(\vec{x}_k)}\right)$
  $\vec{p}_{k+1} \leftarrow -\nabla f(\vec{x}_{k+1}) + \beta_{k+1}\,\vec{p}_k$ `// bend by the old direction`
  if $\nabla f(\vec{x}_{k+1})^{\mathsf{T}}\vec{p}_{k+1} \geq 0$ **then**
    $\vec{p}_{k+1} \leftarrow -\nabla f(\vec{x}_{k+1})$ `// not downhill: restart`
  end
  $k \leftarrow k + 1$
end
return $\vec{x}^* = \vec{x}_k$