Problem A: Use the Θ-notation to determine the rate of growth of the following functions:

Function	Θ estimate
$5n + 3n^2 + 3$	
$17n + 3n^2 \log n + 1$	
$7n^9 + (1.5)^n$	
$n^3 4^n + 5^n + 16\sqrt{n}$	
$\sqrt{n} + 11 \log n$	

Problem B: For each piece of pseudo-code below, give its asymptotic running time as a function of n. Express this running time using the $\Theta()$ notation. (You don't need to give any justification.)

Pseudo-code	Running time

for $i \leftarrow 1$ **to** $2n$ **do**
  for $j \leftarrow 1$ **to** i **do**
  $x \leftarrow 2x + 7$	

$j \leftarrow 1$
while $j < n$ **do**
  $x \leftarrow 2x + 7$
  $j \leftarrow j + 2$	

for $i \leftarrow 1$ **to** n **do**
  $j \leftarrow 1$
  while $j < n$
  $x \leftarrow 2x + 7$
  $j \leftarrow 3j$	

for $i \leftarrow n/2$ **to** n **do**
  $x \leftarrow 2x + 7$
for $j \leftarrow 1$ **to** $3n$ **do**
  $x \leftarrow 2x + 7$	

Note 1: "$\leftarrow$" denotes the assignment statement. The scope of and nesting loops is indicated by the indentation.

Problem C: Use the Θ-notation to determine the rate of growth of the following functions:

Function	big-Θ estimate
$5n + 3n^4 + 3$	
$n \log^2 n + n^{1.5} + \sqrt{n}$	
$17\sqrt{n} + n3^n \log n + 4^n$	
$\sqrt{n} + 11 \log^5 n$	
$1 + 1/\log n$	

Problem D: For each piece of pseudo-code below, give its asymptotic running time as a function of n. Express this running time using the $\Theta()$ notation. Include a brief justification (at most 15 words).

Pseudo-code	Running time	Justification

for $i \leftarrow 1$ **to** n **do**
  $z \leftarrow z + 5$
  $k \leftarrow 1$
  while $k < n$ **do**
  $z \leftarrow z^2$
  $k \leftarrow 2k$		

for $i \leftarrow 1$ **to** $2n + 3$ **do**
  $z \leftarrow z + 5$
for $i \leftarrow 1$ **to** $7n$ **do**
  $z \leftarrow z^2$		

$j \leftarrow 1$
while $j < n$ **do**
  $z \leftarrow z + 5$
  for $i \leftarrow 1$ **to** j **do**
  $z \leftarrow z^2$
  $j \leftarrow 2j$		

for $i \leftarrow 1$ **to** n **do**
  $z \leftarrow z + 2$
  for $j \leftarrow 1$ **to** i **do**
  $z \leftarrow z^2$		

Note: "$\leftarrow$" denotes the assignment statement. The scope and nesting of loops is indicated by the indentation.

Problem E: For each piece of pseudo-code below, give its asymptotic running time as a function of n. Express this running time using the $\Theta()$ notation. Include a brief justification (at most 25 words).

Pseudo-code	Running time	Justification

for $i \leftarrow 1$ **to** $3n^2$ **do**
  $x \leftarrow x^2$
for $j \leftarrow 1$ **to** $n+3$ **do**
  $z \leftarrow x + z$		

for $i \leftarrow 1$ **to** n **do**
  $j \leftarrow 1$
  while $j < n$ **do**
  $j \leftarrow 4j$
  $x \leftarrow j \cdot x$		

for $i \leftarrow 1$ **to** n^2 **do**
  $k \leftarrow 1$
  while $k < n$
  $x \leftarrow x^2$
  $k \leftarrow k + 3$		

for $i \leftarrow n/2$ **to** n **do**
  $x \leftarrow 2x - 1$
  for $j \leftarrow 1$ **to** $2i$ **do**
  $x \leftarrow 2j \cdot x$		

$k \leftarrow 1$
for $i \leftarrow 1$ **to** n **do**
  while $k < 9i$ **do**
  $k \leftarrow k + 1$
  $x \leftarrow x^2$		

Note 1: "$\leftarrow$" denotes the assignment statement. The scope and nesting of loops is indicated by the indentation.