

- 1) (3 pts) Write the assignment statements below using F90 syntax. Your answers should compile and correctly evaluate in double precision if they were to be typed into a program. Assume all variables are double precision.

a) $y = \sqrt{2x^2 - 5.4x + 6.5}$

b) $z = e^{x^3 - 1}$

c) $a = \frac{1}{1 + \frac{1}{\tan(b^2 - \pi)}}$

a) $y = \text{SQRT}(2 * X ** 2 - 5.4d0 * X + 6.5d0)$

b) $z = \text{EXP}(X ** 3 - 1)$

c) $a = 1 / (1 + 1 / \text{TAN}(b ** 2 - dpi))$

- 2) (3 pts) Billy Joe Jim Bob wrote the program below. Although he used unusual variable names, the calculation is quite common. What is his program computing? You should describe what the computation is doing in terms of a math problem, not narrate the steps.

```
PROGRAM test
USE const
IMPLICIT NONE
REAL(KIND=dp) :: apple, orange, banana, carrot, lettuce
WRITE(*,*) 'Input orange, banana, carrot, lettuce'
READ(*,*) orange, banana, carrot, lettuce
apple = SQRT((orange-banana)**2+(carrot-lettuce)**2)
WRITE(*,*) 'apple = ', apple
END PROGRAM test
```

apple = distance between the points (orange, carrot) and (banana, lettuce)

- 3) (3 pts) If i, j and k are integer variables, a is a double precision variable and $i = -2, j = 5, k = 3$, what is the value of a in the assignment statement below?

$$a = (3*j/k)*(3*i/j)*(3*k/i)$$

$$= (3 \cdot 5 / 3) \cdot (3 \cdot (-2) / 5) \cdot (3 \cdot 3 / -2)$$

$$= (15 / 3) \cdot (-6 / 5) \cdot (9 / -2) \leftarrow \text{all integer divisions}$$

$$= 5 \cdot (-1) \cdot (-4) = 20 \text{ (double)}$$

- 4) (2 pts) Explain why you should never perform an equality test on two double precision values.

due to rounding errors in floating point calculations, exact equality is extremely rare and the test will fail most of the time.

- 5) (4 pts) The hyperbolic tangent function is defined in terms of the exponential function via the formula

$$\tanh(x) = \frac{e^x - e^{-x}}{e^x + e^{-x}}$$

Sally Simpson wanted to check if her compiler was correct by computing both sides of this equation, then computing the relative error between the two values she obtained. Her code is given below. Explain why her program is not correct.

```
PROGRAM test
USE const
IMPLICIT NONE
REAL(KIND=dp) :: x,a,b,error
WRITE(*,*) 'input x'
READ(*,*) x
a = TANH(x)
b = (EXP(x) - EXP(-x)) / (EXP(x) + EXP(-x))
error = a-b
WRITE(*,*) 'Error = ',error
END PROGRAM test
```

← missing () in denominator

this is absolute, not relative error.

- 6) (6 pts) Find and correct all syntax and logic errors in the program below. The program should be computing

$$y = \begin{cases} \sqrt{x^2 - 1} + \frac{1}{x^2} & \text{if } x > 2 \\ \sqrt{x} & \text{if } -2 \leq x \leq 2 \\ \sqrt{x^2 + 1} - \frac{1}{x^2} & \text{if } x < -2 \end{cases}$$

```
PROGRAM test
IMPLICIT NONE
USE const
INTEGER :: x
REAL(KIND=dp) :: y, x
WRITE(*,*) 'Input x'
READ(*,*) x
IF(-2 <= x <= 2)
  y = SQRT(x)
ELSEIF(x > 2) THEN
  y = SQRT(x**2-1) + 1/x**2
ELSE
  y = SQRT(x**2+1) - 1/x**2
END IF
WRITE(*,*) 'y = ',y
END PROGRAM test
```

⇒ swap these 2 lines

—— ((-2 <= x). AND. (x <= 2) THEN

7) Assume that a, b, c and d are double precision and that $a = 1, b = 1, c = 2$ and $d = -3$. Consider the IF-THEN block below.

- a) (2 pts) Which of the 4 messages will be printed to the screen? Show your work.
 b) (2 pts) Which branch can you immediately conclude will never be taken regardless of the values of a, b, c and d ? Why?

```

IF(d**2 - c**2 < a**2 - b**2 ) THEN
    WRITE(*,*) 'Message 1'
ELSEIF((a < b).OR.(ABS(d) >= b + c)) THEN
    WRITE(*,*) 'Message 2'
ELSEIF(SQRT(a+c) < 0) THEN
    WRITE(*,*) 'Message 3'
ELSE
    WRITE(*,*) 'Message 4'
ENDIF
    
```

First clause: $d^2 - c^2 = (-3)^2 - (2)^2 = 5$
 $a^2 - b^2 = 1^2 - 1^2 = 0$ } false

Second clause: $a < b$ false
 $|d| \geq b + c$
 $| -3 | \geq 1 + 2$
 $3 \geq 1 + 2$ } true } true

→ Message 2 is printed

Message 3 never printed because $\sqrt{a+c}$ can't be < 0 .