

# NAG Toolbox for MATLAB

## s01ea

### 1 Purpose

s01ea evaluates the exponential function  $e^z$ , for *complex\*16*  $z$ .

### 2 Syntax

```
[result, ifail] = s01ea(z)
```

### 3 Description

s01ea evaluates the exponential function  $e^z$ , taking care to avoid machine overflow, and giving a warning if the result cannot be computed to more than half precision. The function is evaluated as  $e^z = e^x(\cos y + i \sin y)$ , where  $x$  and  $y$  are the real and imaginary parts respectively of  $z$ .

Since  $\cos y$  and  $\sin y$  are less than or equal to 1 in magnitude, it is possible that  $e^x$  may overflow although  $e^x \cos y$  or  $e^x \sin y$  does not. In this case the alternative formula  $\text{sign}(\cos y)e^{x+\ln|\cos y|}$  is used for the real part of the result, and  $\text{sign}(\sin y)e^{x+\ln|\sin y|}$  for the imaginary part. If either part of the result still overflows, a warning is returned through parameter **ifail**.

If  $\text{Im}(z)$  is too large, precision may be lost in the evaluation of  $\sin y$  and  $\cos y$ . Again, a warning is returned through **ifail**.

### 4 References

None.

### 5 Parameters

#### 5.1 Compulsory Input Parameters

1: **z** – complex scalar

The argument  $z$  of the function.

#### 5.2 Optional Input Parameters

None.

#### 5.3 Input Parameters Omitted from the MATLAB Interface

None.

#### 5.4 Output Parameters

1: **result** – complex scalar

The result of the function.

2: **ifail** – int32 scalar

0 unless the function detects an error (see Section 6).

## 6 Error Indicators and Warnings

Errors or warnings detected by the function:

**ifail** = 1

The real part of the result overflows, and is set to the largest safe number with the correct sign. The imaginary part of the result is meaningful.

**ifail** = 2

The imaginary part of the result overflows, and is set to the largest safe number with the correct sign. The real part of the result is meaningful.

**ifail** = 3

Both real and imaginary parts of the result overflow, and are set to the largest safe number with the correct signs.

**ifail** = 4

The computed result is accurate to less than half precision, due to the size of  $\text{Im}(z)$ .

**ifail** = 5

The computed result has no precision, due to the size of  $\text{Im}(z)$ , and is set to zero.

## 7 Accuracy

Accuracy is limited in general only by the accuracy of the standard functions in the computation of  $\sin y$ ,  $\cos y$  and  $e^x$ , where  $x = \text{Re}(z)$ ,  $y = \text{Im}(z)$ . As  $y$  gets larger, precision will probably be lost due to argument reduction in the evaluation of the sine and cosine functions, until the warning error **ifail** = 4 occurs when  $y$  gets larger than  $\sqrt{1/\epsilon}$ , where  $\epsilon$  is the *machine precision*. Note that on some machines, the intrinsic functions SIN and COS will not operate on arguments larger than about  $\sqrt{1/\epsilon}$ , and so **ifail** can never return as 4.

In the comparatively rare event that the result is computed by the formulae  $\text{sign}(\cos y)e^{x+\ln|\cos y|}$  and  $\text{sign}(\sin y)e^{x+\ln|\sin y|}$ , a further small loss of accuracy may be expected due to rounding errors in the logarithmic function.

## 8 Further Comments

None.

## 9 Example

```
z = complex(1, +0);
[result, ifail] = s01ea(z)

result =
    2.7183
ifail =
    0
```