Matlab Reference Sheet for Physics

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This PDF contains instructions on how to use Matlab to do mathematical calculations that I've used at least somewhat frequently while doing my undergraduate physics degree. Still a work in progress. You are to free to use/edit it as you see fit.

Contents

1 Simplify & Expand Expressions

Example: $e^{ix} - (\cos x + i \sin x) + (x + 2)(x - 1)$

In Matlab:

```
>> syms x
>> eqn = exp(i*x) - (cos(x) + i*sin(x)) + (x+2)*(x-1)
>> simplify(eqn)
```

Doing expand(fun) would have only expanded the product but not simplified the expression by cancelling the sin, cos, & eˆ(ix).

2 System of Equations

Example: Solve for x & y

$$s = x \cos \phi + y \sin \phi$$

$$\phi = -x \sin \phi + y \cos \phi$$

In Matlab:

```
>> syms x, y, phi, s
>> eqns = [cos(phi)*x + sin(phi)*y == s, -sin(phi)*x + cos(phi)*y == phi]
>> S = solve(eqns,[x y])
```

To display solution for x type S.x and similary for y type S.y. Or type:
M = [S.x, S.y]
to get the solution matrix where each row of the matrix corresponds to a solution to the system. If you wanted to solve for phi and s the command would be solve(eqns, [theta s]) instead. Although the equation may not be easily solvable for Matlab due to its non- linearity.

3 Differentiation

Single Variable Derivative:

Example: $\frac{d}{dx}(\ln(x^2)) = \frac{2}{x}$

In Matlab:

```
>> syms x
>> diff(log(x^2))
```

4 Integration

Symbolic Single Integral:

Example: $\int_0^R 2\pi r \sin\theta \, dr = \pi R^2 \sin\theta$

In Matlab:

```
>> syms r theta R
>> fun = 2*pi*r*sin(theta)
>> int(fun, "r", 0, R)
```

Symbolic Double Integral:

Example: $\int_0^L \int_0^{x^2+1} xy \, dy \, dx = \frac{L^2(L^4+3L^2+3)}{12}$

In Matlab:

```
>> syms x y L
>> fun = x*y
>> int(int(fun, "y", 0, x^2 + 1), "x", 0, L)
```

For triple integrals simply wrap expression in another int().

5 Matrix Algebra

Finding Eigenvalues and Eigenvectors:

Example: $\begin{bmatrix} 1 & 6 & 0 \\ -3 & 1 & 0 \\ 0 & 4 & 1 \end{bmatrix}$

In Matlab:

```
>> A = [1 6 0; -3 1 0; 0 4 1]
>> [V,D] = eig(sym(A))
```

Returns a diagonal matrix D with eigen values along the diagonal and a matrix V whose columns are the corresponding eigen vectors. Use sym(A) instead of just A so that answer is given symbolically instead of numerically, e.i. $\lambda_2 = 1$ - 2^(1/2)*3i instead of $\lambda_2 = 1.0000$ - 4.2426i.

Invert Matrix:

Example: $\begin{bmatrix} 1 & 6 & 0 \\ -3 & 1 & 0 \\ 0 & 4 & 1 \end{bmatrix}$

In Matlab:

```
>> A = [1 6 0; -3 1 0; 0 4 1]
>> inv(sym(A))
```

More advanced matrix example:

Find a matrix U such that $UAU^{-1} = B$.

Where $A = \begin{bmatrix} -\frac{1}{2} & -\sqrt{3} \\ \frac{\sqrt{3}}{4} & -\frac{1}{2} \end{bmatrix}$ and $B = \begin{bmatrix} -\frac{1}{2} & -\frac{\sqrt{3}}{2} \\ \frac{\sqrt{3}}{2} & -\frac{1}{2} \end{bmatrix}$.

In Matlab:

```
>> syms A B U a b c d
>> U = [a b; c d]
>> A = sym([-1/2 -sqrt(3); sqrt(3)/4 -1/2])
>> B = sym([-1/2 -sqrt(3)/2; sqrt(3)/2 -1/2])
>> T = U*A*inv(U)
>> eqns = [T(1,1) == B(1,1), T(1,2) == B(1,2), T(2,1) == B(2,1), T(2,2) == B(2,
2) ]
>> S = solve(eqns, [a b c d])
>> M = [S.a, S.b, S.c, S.d]
```

At the end M should be printed as a 2x4 matrix with it's rows corresponding to 2 distinct solutions i.e. 2 different matrices that satisfy the relationship above.

6 Differential Equations