**ENEL102, fall term 2018**

**Assignment 6**

**Matlab Symbolic Math**

**Chapter 11**

**Due date: Dec 3**

This assignment will be based on questions taken from Chapter 11 of the Gilat textbook. Suggest you review this before answering the questions. As usual, cut&paste the questions into a word document and fill in the answers. Then submit your Word document on D2L. ………………………………………………………………………………………………………………………………..………………………………………………………………………………………………………………………………..

**Q1** Consider the polynomial equation of



expand this equation symbolically. Then use factor() the result to ensure you get the same equation back.

**(Matlab input)**

syms x

y = (x+1)^3\*(x+2)\*(x+3);

T = expand(y)

factor(T)

**(Matlab Response)**

T = x^5+ 8\*x^4 + 24\*x^3 + 34\*x^2 + 23\*x + 6

ans = [x+3, x+2, x+1, x+1, x+1]

**Q2** Find the coefficient of the term of the polynomial



hint use coeffs()

**(Matlab input)**

syms x S

y = (x+1)^3\*(x+2)\*(x+3)

T = expand(y)

S = T

[coeff term] = coeffs(S)

for i = 1:6

if (term(i) == x^4)

c = coeff(i);

disp(c);

end

end

**(Matlab Response)**

8

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**Q3** Next consider the polynomial equation of



Collect the coefficients of the variable . Give the coefficient of .

**(Matlab input)**

syms x t S

y = (x+1)^2\*(x+2\*t)^3\*(x+3)+t^2

T = expand(y)

S = T;

[coeff term] = coeffs(S)

for i = 1:17

for n = 1:5

if (term(i) == t\*x^n)

c = coeff(i)

end

end

end

for i = 1:17

if (term(i) == t^2)

c = coeff(i);

disp(c);

end

end

**(Matlab Response)**

c = 6

c = 30

c = 42

c = 18

c = 1

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**Q4 Find the inverse of**  using the symbolic toolbox.

**(Matlab input)**

syms a

A = sym([a 1; 1 a]);

inv(A)

**(Matlab Response)**

ans =

[ a/(a^2 - 1), -1/(a^2 - 1)]

[ -1/(a^2 - 1), a/(a^2 - 1)]

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**Q5** The probability density function of a normal random variable, x, with a mean of and a variance of v is given as



The probability that x is in the region between a lower bound of A and an upper bound of B is then



Determine a symbolic expression of this probability. You will likely get an answer which is based on the error function or erf() which is defined as



**(Matlab input)**

syms a v x A B

p = (1/sqrt(2\*pi\*v))\*exp(-(x-a)^2/(2\*v))

Pr = int(p,[A B])

**(Matlab Response)**

Pr =

-(erf((2^(1/2)\*(A - a)\*(1/v)^(1/2))/2) - erf((2^(1/2)\*(B - a)\*(1/v)^(1/2))/2))/(2\*v^(1/2)\*(1/v)^(1/2))

**Q6** In certain problems we are interested in determining the change in the probability function of  in Q5 as the parameteris varied. As such we are interested in determining . Starting with your answer to Q5, use Matlab to determine this derivative in symbolic form. Then solve this derivative directly by hand using your calculus prowess and show that Matlab’s answer is indeed correct.

**(Matlab input)**

Pr\_d = diff(Pr, a)

**(Matlab output)**

Pr\_d =

((2^(1/2)\*exp(-(A - a)^2/(2\*v))\*(1/v)^(1/2))/pi^(1/2) - (2^(1/2)\*exp(-(B - a)^2/(2\*v))\*(1/v)^(1/2))/pi^(1/2))/(2\*v^(1/2)\*(1/v)^(1/2))

**Q7** Solve the differential equation given as



using the symbolic toolbox using dsolve() and interpret the output.

**(Matlab input)**

syms x(t)

eqn = diff(x,t) == x;

cond = x(0) == 1;

x\_sol(t) = dsolve(eqn, cond)

**(Matlab output)**

x\_sol(t) =

exp(t)

**Q8** A transfer function of a system is given as



Find the step response and unit slope ramp response based on the symbolic inverse Laplace transform. That is use ilaplace(). Plot the responses with ezplot().

**(Matlab input)**

syms s

H = 1/(s+1);

step\_response = H \* 1/s;

unit\_ramp = H \* 1/(s^2)

p1 = ilaplace(unit\_ramp);

p2 = ilaplace(step\_response)

**(Matlab output)**

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**Q9** The probability density function of a normal random variable, x, with a mean of 0 and a variance of 1 is given as



Suppose we want to approximate p(x) as a polynomial around the neighborhood of x=1. Use a fourth order Taylor expansion to do this and then compare the polynomial expansion with p(x) in a plot.

**(Matlab input)**

syms x

p = (1/(sqrt(2\*pi)))\*exp(-x^2/2);

t4 = taylor(p,x,'ExpansionPoint',1, 'Order',4)

fplot([t4 p])

xlim([-6 6])

legend('fourth order taylor expansion', 'p(x)')

**(Matlab Response)**

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**Q10** Generalize the Taylor expansion problem of **Q9** to the more general expression of the Gaussian probability function as 

where v is the variance and u is the mean. This time do a 4th order Taylor expansion around the expansion point of x=1. Specifically find the coefficient of x3. (hint use coeffs())

**(Matlab input)**

syms x u v

p = (1/(sqrt(2\*pi\*v)))\*exp(-((x-u)^2)/(2\*v));

t4 = taylor(p,x,1,'Order',4)

[coeff term] = coeffs(t4, x)

c = coeff(term == x^3)

**(Matlab Response)**

c =

-(2^(1/2)\*exp(-(u - 1)^2/(2\*v))\*((2\*u - 2)/(8\*v^2) - ((2\*u - 2)\*((2\*u - 2)^2/(24\*v^2) - 1/(4\*v)))/(2\*v)))/(2\*v^(1/2)\*pi^(1/2))

**Q11** Take the coefficient of x3 as calculated in Q10 and plot it for v=2 and u in the range of -2<u<3.

**(Matlab input)**

syms x u v

p = (1/(sqrt(2\*pi\*v)))\*exp(-((x-u)^2)/(2\*v));

t4 = taylor(p,x,1,'Order',4)

[coeff term] = coeffs(t4, x)

c = coeff(term == x^3);

c = subs(c,v,2);

c = subs(c, u, linspace(-2,3));

plot(linspace(-5,5), c)

**(Matlab Response)**

