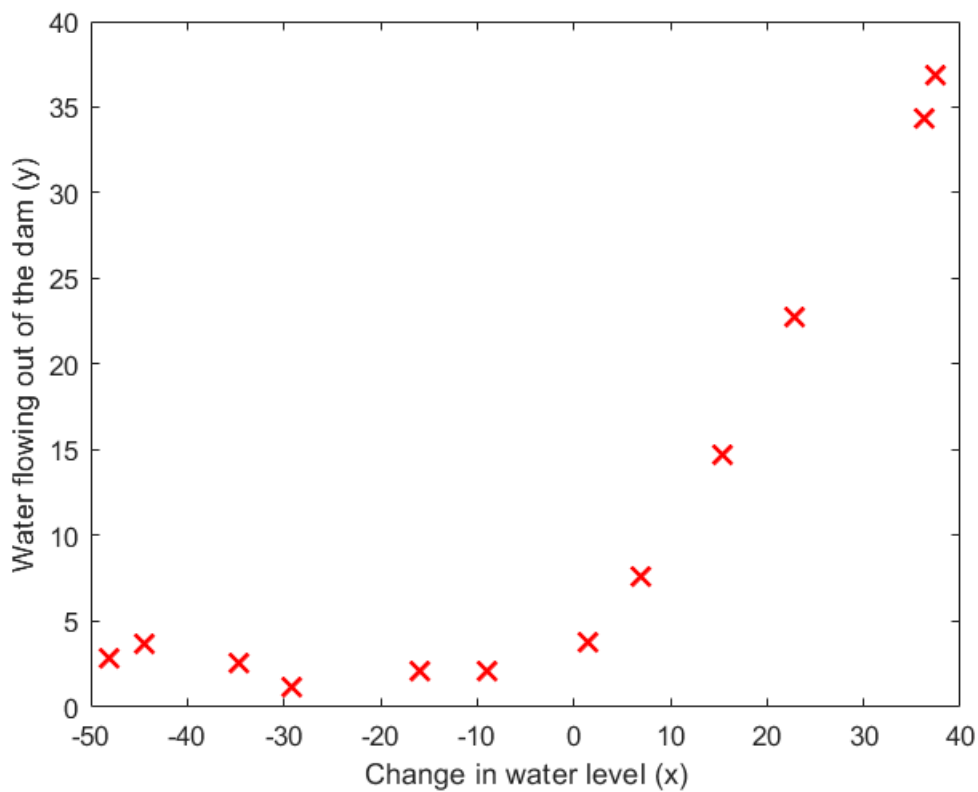


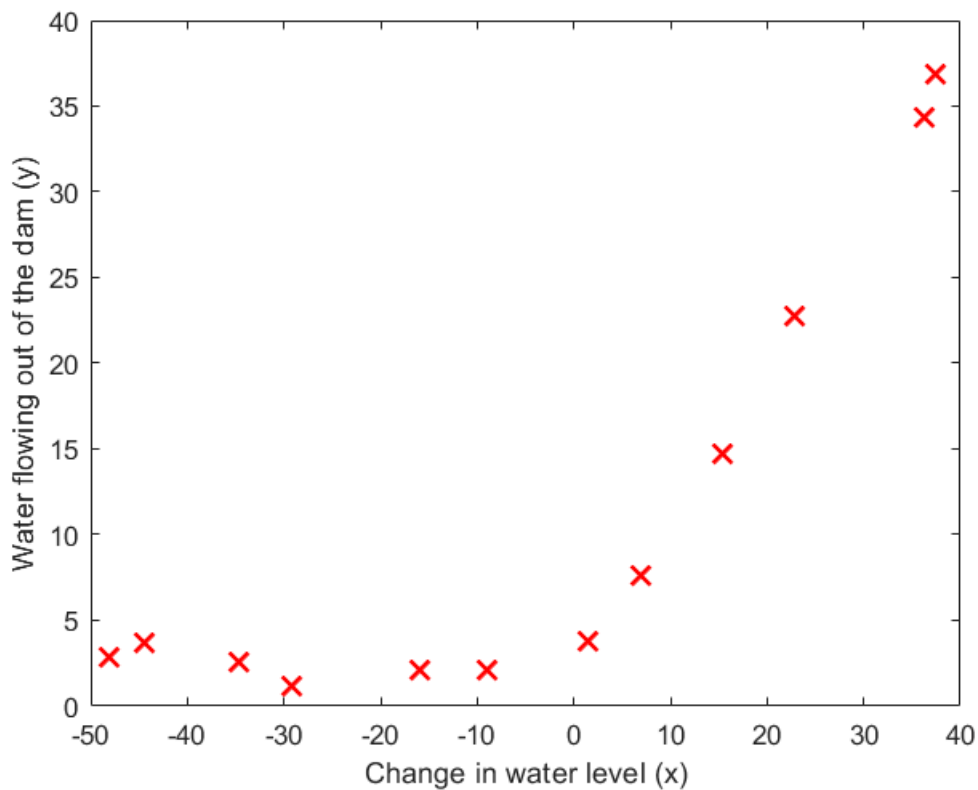
1. Загрузите данные **ex3data1.mat** из файла.

```
load ('ex5data1.mat');
```



2. Постройте график, где по осям откладываются X и y из обучающей выборки.

```
figure;  
plot(X, y, 'rx', 'MarkerSize', 10, 'LineWidth', 1.5);  
xlabel('Change in water level (x)');  
ylabel('Water flowing out of the dam (y)');
```



3. Реализуйте функцию стоимости потерь для линейной регрессии с L2-регуляризацией.

```
function [J, grad] = linearRegCostFunction(X, y, theta, lambda)

m = length(y);
J = 0;
grad = zeros(size(theta));
m = length(y);
h_theta = X * theta;
J = 1/(2*m) * (h_theta - y)' * (h_theta - y) + ...
(lambda/(2*m)) * (theta(2:length(theta)))' * theta(2:length(theta));
thetaZero = theta;
thetaZero(1) = 0;
grad = ((1 / m) * (h_theta - y)' * X) + ...
lambda / m * thetaZero';
grad = grad(:);

end
```

4. Реализуйте функцию градиентного спуска для линейной регрессии с L2-регуляризацией.

```
function [theta] = trainLinearReg(X, y, lambda)

initial_theta = zeros(size(X, 2), 1);
costFunction = @(t) linearRegCostFunction(X, y, t, lambda);
options = optimset('MaxIter', 200, 'GradObj', 'on');
theta = fmincg(costFunction, initial_theta, options);

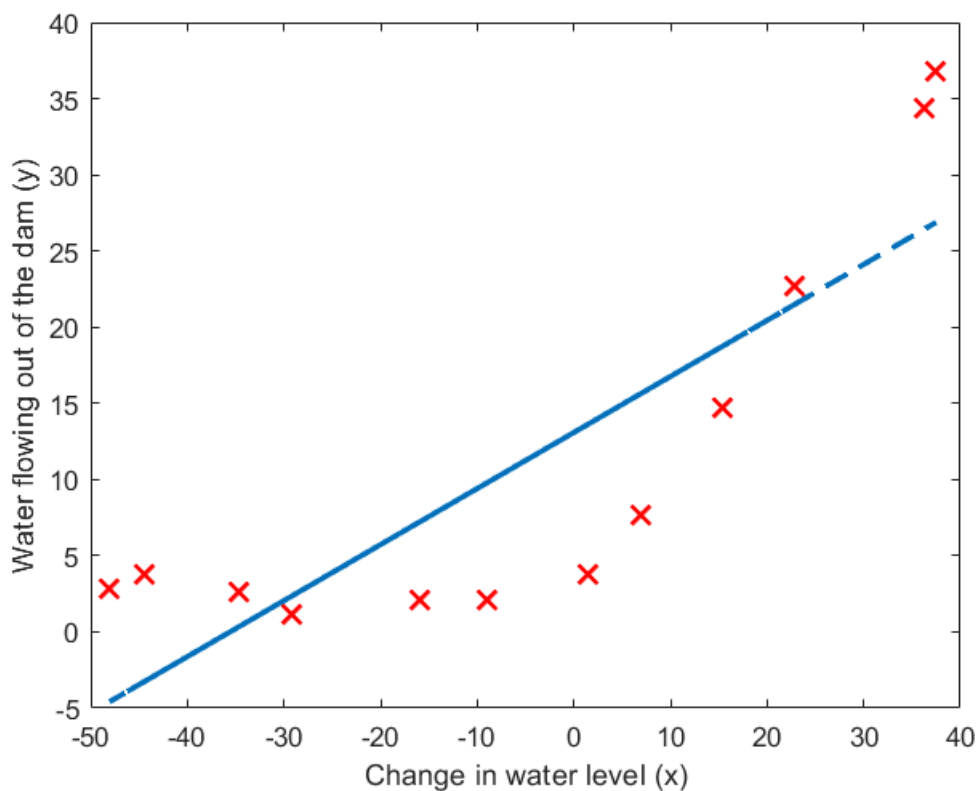
end
```

5. Постройте модель линейной регрессии с коэффициентом регуляризации 0 и постройте график полученной функции совместно с графиком из пункта 2. Почему регуляризация в данном случае не сработает?

```
lambda = 0;
[theta] = trainLinearReg([ones(m, 1) X], y, lambda);
```

```
Iteration    1 | Cost: 1.052435e+02
Iteration    2 | Cost: 2.237391e+01
Iteration    3 | Cost: 2.237391e+01
Iteration    4 | Cost: 2.237391e+01
Iteration    5 | Cost: 2.237391e+01
Iteration    6 | Cost: 2.237391e+01
```

```
figure;
plot(X, y, 'rx', 'MarkerSize', 10, 'LineWidth', 1.5);
xlabel('Change in water level (x)');
ylabel('Water flowing out of the dam (y)');
hold on;
plot(X, [ones(m, 1) X]*theta, '--', 'LineWidth', 2)
hold off;
```



Регуляризация не сработает потому что слишком маленькая размерность тета.

6. Постройте график процесса обучения (learning curves) для обучающей и валидационной выборки. По оси абсцисс откладывается число элементов из обучающей выборки, а по оси ординат - ошибка

(значение функции потерь) для обучающей выборки (первая кривая) и валидационной выборки (вторая кривая). Какой вывод можно сделать по построенному графику?

```
lambda = 0;  
[error_train, error_val] = learningCurve([ones(m, 1) X], y, [ones(size(Xval, 1), 1) Xva
```

Iteration	1	Cost: 2.663868e-01
Iteration	2	Cost: 3.944305e-31
Iteration	3	Cost: 0.000000e+00
Iteration	1	Cost: 4.282328e-01
Iteration	2	Cost: 8.295365e-30
Iteration	3	Cost: 4.930381e-32
Iteration	1	Cost: 1.021540e+02
Iteration	2	Cost: 3.286595e+00
Iteration	1	Cost: 1.438726e+02
Iteration	2	Cost: 1.035224e+02
Iteration	3	Cost: 7.536716e+01
Iteration	4	Cost: 1.615422e+01
Iteration	5	Cost: 3.619255e+00
Iteration	6	Cost: 2.843147e+00
Iteration	7	Cost: 2.842791e+00
Iteration	8	Cost: 2.842765e+00
Iteration	9	Cost: 2.842679e+00
Iteration	10	Cost: 2.842679e+00
Iteration	11	Cost: 2.842679e+00
Iteration	12	Cost: 2.842678e+00
Iteration	13	Cost: 2.842678e+00
Iteration	14	Cost: 2.842678e+00
Iteration	15	Cost: 2.842678e+00
Iteration	16	Cost: 2.842678e+00
Iteration	17	Cost: 2.842678e+00
Iteration	18	Cost: 2.842678e+00
Iteration	19	Cost: 2.842678e+00
Iteration	20	Cost: 2.842678e+00
Iteration	21	Cost: 2.842678e+00
Iteration	22	Cost: 2.842678e+00
Iteration	23	Cost: 2.842678e+00
Iteration	24	Cost: 2.842678e+00
Iteration	25	Cost: 2.842678e+00
Iteration	26	Cost: 2.842678e+00
Iteration	27	Cost: 2.842678e+00
Iteration	28	Cost: 2.842678e+00
Iteration	29	Cost: 2.842678e+00
Iteration	30	Cost: 2.842678e+00
Iteration	32	Cost: 2.842678e+00
Iteration	1	Cost: 1.592641e+02
Iteration	2	Cost: 2.404966e+01
Iteration	3	Cost: 2.354137e+01
Iteration	4	Cost: 2.281160e+01
Iteration	5	Cost: 2.276969e+01
Iteration	6	Cost: 2.224060e+01
Iteration	7	Cost: 1.920606e+01
Iteration	8	Cost: 1.475292e+01
Iteration	9	Cost: 1.430565e+01
Iteration	10	Cost: 1.388881e+01
Iteration	11	Cost: 1.327330e+01
Iteration	12	Cost: 1.323519e+01
Iteration	13	Cost: 1.319411e+01
Iteration	14	Cost: 1.317355e+01
Iteration	15	Cost: 1.315411e+01
Iteration	16	Cost: 1.315405e+01
Iteration	17	Cost: 1.315405e+01
Iteration	18	Cost: 1.315405e+01

Iteration	19	Cost: 1.315405e+01
Iteration	20	Cost: 1.315405e+01
Iteration	21	Cost: 1.315405e+01
Iteration	22	Cost: 1.315405e+01
Iteration	23	Cost: 1.315405e+01
Iteration	24	Cost: 1.315405e+01
Iteration	26	Cost: 1.315405e+01
Iteration	28	Cost: 1.315405e+01
Iteration	30	Cost: 1.315405e+01
Iteration	1	Cost: 1.531141e+02
Iteration	2	Cost: 1.350947e+02
Iteration	3	Cost: 1.137334e+02
Iteration	4	Cost: 4.404199e+01
Iteration	5	Cost: 2.957435e+01
Iteration	6	Cost: 2.719561e+01
Iteration	7	Cost: 1.949283e+01
Iteration	8	Cost: 1.949128e+01
Iteration	9	Cost: 1.945708e+01
Iteration	10	Cost: 1.944472e+01
Iteration	11	Cost: 1.944472e+01
Iteration	12	Cost: 1.944471e+01
Iteration	13	Cost: 1.944453e+01
Iteration	14	Cost: 1.944425e+01
Iteration	15	Cost: 1.944411e+01
Iteration	16	Cost: 1.944396e+01
Iteration	17	Cost: 1.944396e+01
Iteration	18	Cost: 1.944396e+01
Iteration	19	Cost: 1.944396e+01
Iteration	20	Cost: 1.944396e+01
Iteration	21	Cost: 1.944396e+01
Iteration	22	Cost: 1.944396e+01
Iteration	23	Cost: 1.944396e+01
Iteration	24	Cost: 1.944396e+01
Iteration	25	Cost: 1.944396e+01
Iteration	26	Cost: 1.944396e+01
Iteration	1	Cost: 1.383936e+02
Iteration	2	Cost: 1.210275e+02
Iteration	3	Cost: 1.013004e+02
Iteration	4	Cost: 3.457729e+01
Iteration	5	Cost: 2.808710e+01
Iteration	6	Cost: 2.732288e+01
Iteration	7	Cost: 2.011513e+01
Iteration	8	Cost: 2.011508e+01
Iteration	9	Cost: 2.010693e+01
Iteration	10	Cost: 2.010640e+01
Iteration	11	Cost: 2.010629e+01
Iteration	12	Cost: 2.010382e+01
Iteration	13	Cost: 2.009852e+01
Iteration	14	Cost: 2.009852e+01
Iteration	15	Cost: 2.009852e+01
Iteration	16	Cost: 2.009852e+01
Iteration	17	Cost: 2.009852e+01
Iteration	18	Cost: 2.009852e+01
Iteration	19	Cost: 2.009852e+01
Iteration	20	Cost: 2.009852e+01
Iteration	21	Cost: 2.009852e+01
Iteration	22	Cost: 2.009852e+01
Iteration	23	Cost: 2.009852e+01
Iteration	24	Cost: 2.009852e+01
Iteration	1	Cost: 1.237772e+02
Iteration	2	Cost: 1.202532e+02
Iteration	3	Cost: 1.195134e+02
Iteration	4	Cost: 9.334231e+01
Iteration	5	Cost: 4.813526e+01
Iteration	6	Cost: 2.650400e+01

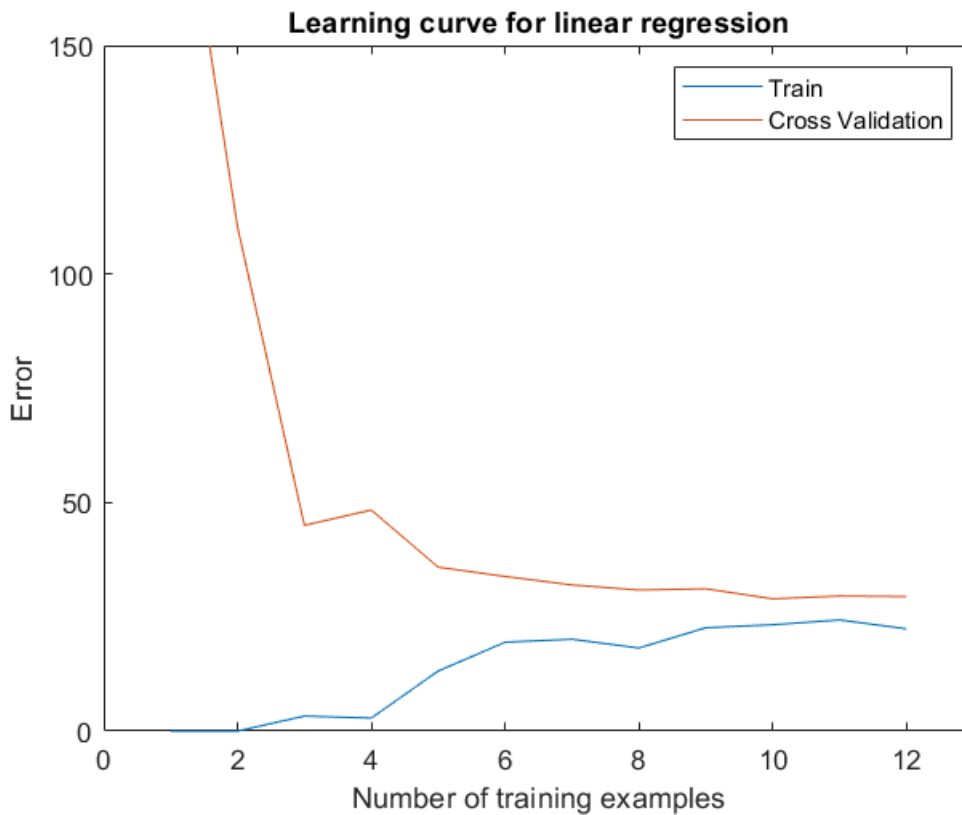
Iteration	7	Cost: 1.927314e+01
Iteration	8	Cost: 1.826693e+01
Iteration	9	Cost: 1.817331e+01
Iteration	10	Cost: 1.817289e+01
Iteration	11	Cost: 1.817288e+01
Iteration	12	Cost: 1.817286e+01
Iteration	13	Cost: 1.817286e+01
Iteration	14	Cost: 1.817286e+01
Iteration	15	Cost: 1.817286e+01
Iteration	16	Cost: 1.817286e+01
Iteration	17	Cost: 1.817286e+01
Iteration	19	Cost: 1.817286e+01
Iteration	20	Cost: 1.817286e+01
Iteration	1	Cost: 1.089984e+02
Iteration	2	Cost: 1.064701e+02
Iteration	3	Cost: 1.054742e+02
Iteration	4	Cost: 2.266786e+01
Iteration	5	Cost: 2.266786e+01
Iteration	6	Cost: 2.266758e+01
Iteration	7	Cost: 2.260941e+01
Iteration	8	Cost: 2.260941e+01
Iteration	10	Cost: 2.260941e+01
Iteration	12	Cost: 2.260941e+01
Iteration	1	Cost: 1.108611e+02
Iteration	2	Cost: 2.497543e+01
Iteration	3	Cost: 2.496421e+01
Iteration	4	Cost: 2.494838e+01
Iteration	5	Cost: 2.493176e+01
Iteration	6	Cost: 2.490652e+01
Iteration	7	Cost: 2.474399e+01
Iteration	8	Cost: 2.326173e+01
Iteration	9	Cost: 2.326173e+01
Iteration	10	Cost: 2.326168e+01
Iteration	11	Cost: 2.326146e+01
Iteration	12	Cost: 2.326146e+01
Iteration	13	Cost: 2.326146e+01
Iteration	14	Cost: 2.326146e+01
Iteration	15	Cost: 2.326146e+01
Iteration	16	Cost: 2.326146e+01
Iteration	17	Cost: 2.326146e+01
Iteration	1	Cost: 1.023394e+02
Iteration	2	Cost: 2.443039e+01
Iteration	3	Cost: 2.443033e+01
Iteration	4	Cost: 2.442972e+01
Iteration	5	Cost: 2.441042e+01
Iteration	6	Cost: 2.435852e+01
Iteration	7	Cost: 2.431735e+01
Iteration	8	Cost: 2.431733e+01
Iteration	9	Cost: 2.431727e+01
Iteration	10	Cost: 2.431725e+01
Iteration	11	Cost: 2.431725e+01
Iteration	12	Cost: 2.431725e+01
Iteration	14	Cost: 2.431725e+01
Iteration	1	Cost: 1.052435e+02
Iteration	2	Cost: 2.237391e+01
Iteration	3	Cost: 2.237391e+01
Iteration	4	Cost: 2.237391e+01
Iteration	5	Cost: 2.237391e+01
Iteration	6	Cost: 2.237391e+01

```

plot(1:m, error_train, 1:m, error_val);
title('Learning curve for linear regression')
legend('Train', 'Cross Validation')

```

```
xlabel('Number of training examples')
ylabel('Error')
axis([0 13 0 150])
```



```
fprintf('# Training Examples\tTrain Error\tCross Validation Error\n');
```

```
# Training Examples Train Error Cross Validation Error
```

```
for i = 1:m
    fprintf(' \t%d\t\t%f\t%f\n', i, error_train(i), error_val(i));
end
```

```
1  0.000000 205.121096
2  0.000000 110.300366
3  3.286595 45.010231
4  2.842678 48.368911
5  13.154049 35.865165
6  19.443963 33.829962
7  20.098522 31.970986
8  18.172859 30.862446
9  22.609405 31.135998
10 23.261462 28.936207
11 24.317250 29.551432
12 22.373906 29.433818
```

Ошибка на тестовом и валидационном сете высокая. Модель слишком простая чтобы подстроиться под данные.

7. Реализуйте функцию добавления $p - 1$ новых признаков в обучающую выборку ($X_2, X_3, X_4, \dots, X_p$).

```
function [X_poly] = polyFeatures(X, p)
X_poly = zeros(numel(X), p);

m = size(X, 1);

for i=1:m

    poly_feature = zeros(p, 1);

    for j=1:p
        poly_feature(j) = X(i).^j;
    end

    X_poly(i, :) = poly_feature;
end

end
```

8. Поскольку в данной задаче будет использован полином высокой степени, то необходимо перед обучением произвести нормализацию признаков.

9. Обучите модель с коэффициентом регуляризации 0 и $p = 8$.

```
p = 8;

% Map X onto Polynomial Features and Normalize
X_poly = polyFeatures(X, p);
[X_poly, mu, sigma] = featureNormalize(X_poly); % Normalize
X_poly = [ones(m, 1), X_poly]; % Add Ones

% % Map X_poly_test and normalize (using mu and sigma)
X_poly_test = polyFeatures(Xtest, p);
X_poly_test = X_poly_test-mu; % uses implicit expansion instead of bsxfun
X_poly_test = X_poly_test./sigma; % uses implicit expansion instead of bsxfun
X_poly_test = [ones(size(X_poly_test, 1), 1), X_poly_test]; % Add Ones

% Map X_poly_val and normalize (using mu and sigma)
X_poly_val = polyFeatures(Xval, p);
X_poly_val = X_poly_val-mu; % uses implicit expansion instead of bsxfun
X_poly_val = X_poly_val./sigma; % uses implicit expansion instead of bsxfun
X_poly_val = [ones(size(X_poly_val, 1), 1), X_poly_val]; % Add Ones

fprintf('Normalized Training Example 1:\n');
```

Normalized Training Example 1:

```
fprintf(' %f \n', X_poly(1, :));
```

```
1.000000
-0.362141
-0.755087
0.182226
-0.706190
```


0.306618
-0.590878
0.344516
-0.508481

```
lambda = 0;  
[theta] = trainLinearReg(X_poly, y, lambda);
```

Iteration	1	Cost: 8.273077e+01
Iteration	2	Cost: 2.687496e+01
Iteration	3	Cost: 1.327780e+01
Iteration	4	Cost: 3.455324e+00
Iteration	5	Cost: 2.870493e+00
Iteration	6	Cost: 2.404364e+00
Iteration	7	Cost: 2.372779e+00
Iteration	8	Cost: 1.771555e+00
Iteration	9	Cost: 1.210317e+00
Iteration	10	Cost: 9.411245e-01
Iteration	11	Cost: 7.802115e-01
Iteration	12	Cost: 7.270456e-01
Iteration	13	Cost: 6.577683e-01
Iteration	14	Cost: 5.106861e-01
Iteration	15	Cost: 4.734015e-01
Iteration	16	Cost: 4.222337e-01
Iteration	17	Cost: 4.209566e-01
Iteration	18	Cost: 4.179436e-01
Iteration	19	Cost: 4.149038e-01
Iteration	20	Cost: 4.048243e-01
Iteration	21	Cost: 4.003634e-01
Iteration	22	Cost: 3.952067e-01
Iteration	23	Cost: 3.842805e-01
Iteration	24	Cost: 3.514872e-01
Iteration	25	Cost: 3.485057e-01
Iteration	26	Cost: 3.440929e-01
Iteration	27	Cost: 3.433698e-01
Iteration	28	Cost: 3.402403e-01
Iteration	29	Cost: 3.385564e-01
Iteration	30	Cost: 3.371135e-01
Iteration	31	Cost: 3.323856e-01
Iteration	32	Cost: 3.213089e-01
Iteration	33	Cost: 3.198552e-01
Iteration	34	Cost: 3.043161e-01
Iteration	35	Cost: 2.629876e-01
Iteration	36	Cost: 2.530939e-01
Iteration	37	Cost: 2.450565e-01
Iteration	38	Cost: 2.441580e-01
Iteration	39	Cost: 2.407571e-01
Iteration	40	Cost: 2.404626e-01
Iteration	41	Cost: 2.393662e-01
Iteration	42	Cost: 2.392498e-01
Iteration	43	Cost: 2.391169e-01
Iteration	44	Cost: 2.383570e-01
Iteration	45	Cost: 2.382119e-01
Iteration	46	Cost: 2.372786e-01
Iteration	47	Cost: 2.333841e-01
Iteration	48	Cost: 2.326425e-01
Iteration	49	Cost: 2.322579e-01
Iteration	50	Cost: 2.321067e-01
Iteration	51	Cost: 2.316359e-01
Iteration	52	Cost: 2.311190e-01
Iteration	53	Cost: 2.310144e-01
Iteration	54	Cost: 2.296767e-01
Iteration	55	Cost: 2.293098e-01

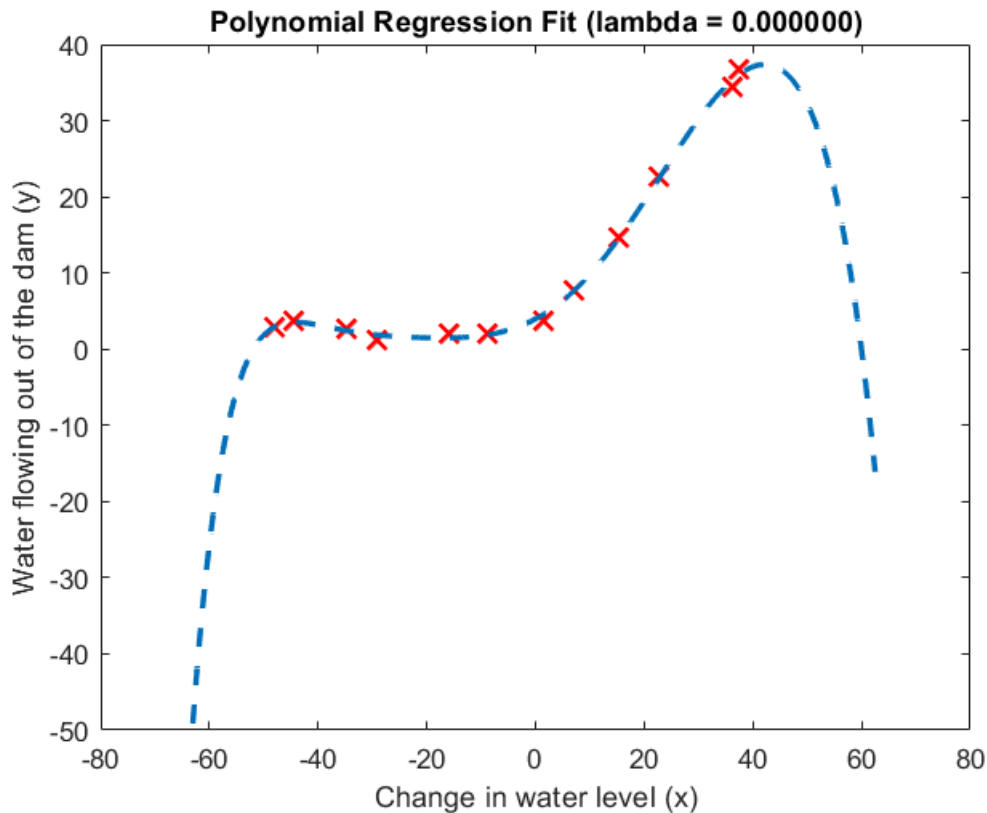
Iteration	56	Cost: 2.289738e-01
Iteration	57	Cost: 2.285946e-01
Iteration	58	Cost: 2.284382e-01
Iteration	59	Cost: 2.283791e-01
Iteration	60	Cost: 2.281269e-01
Iteration	61	Cost: 2.280692e-01
Iteration	62	Cost: 2.279445e-01
Iteration	63	Cost: 2.278727e-01
Iteration	64	Cost: 2.276174e-01
Iteration	65	Cost: 2.275821e-01
Iteration	66	Cost: 2.274535e-01
Iteration	67	Cost: 2.274175e-01
Iteration	68	Cost: 2.272772e-01
Iteration	69	Cost: 2.272474e-01
Iteration	70	Cost: 2.271243e-01
Iteration	71	Cost: 2.270930e-01
Iteration	72	Cost: 2.268701e-01
Iteration	73	Cost: 2.266744e-01
Iteration	74	Cost: 2.236910e-01
Iteration	75	Cost: 2.213602e-01
Iteration	76	Cost: 2.185692e-01
Iteration	77	Cost: 2.180727e-01
Iteration	78	Cost: 2.167949e-01
Iteration	79	Cost: 2.156531e-01
Iteration	80	Cost: 2.108199e-01
Iteration	81	Cost: 2.089561e-01
Iteration	82	Cost: 2.041837e-01
Iteration	83	Cost: 2.011422e-01
Iteration	84	Cost: 2.004799e-01
Iteration	85	Cost: 1.988686e-01
Iteration	86	Cost: 1.964732e-01
Iteration	87	Cost: 1.957600e-01
Iteration	88	Cost: 1.898125e-01
Iteration	89	Cost: 1.880149e-01
Iteration	90	Cost: 1.857863e-01
Iteration	91	Cost: 1.847378e-01
Iteration	92	Cost: 1.808871e-01
Iteration	93	Cost: 1.801229e-01
Iteration	94	Cost: 1.793317e-01
Iteration	95	Cost: 1.792268e-01
Iteration	96	Cost: 1.789535e-01
Iteration	97	Cost: 1.787999e-01
Iteration	98	Cost: 1.787706e-01
Iteration	99	Cost: 1.784343e-01
Iteration	100	Cost: 1.783865e-01
Iteration	101	Cost: 1.782204e-01
Iteration	102	Cost: 1.781227e-01
Iteration	103	Cost: 1.781045e-01
Iteration	104	Cost: 1.780330e-01
Iteration	105	Cost: 1.779761e-01
Iteration	106	Cost: 1.779575e-01
Iteration	107	Cost: 1.778883e-01
Iteration	108	Cost: 1.777697e-01
Iteration	109	Cost: 1.763832e-01
Iteration	110	Cost: 1.761266e-01
Iteration	111	Cost: 1.755509e-01
Iteration	112	Cost: 1.752843e-01
Iteration	113	Cost: 1.743353e-01
Iteration	114	Cost: 1.742830e-01
Iteration	115	Cost: 1.741572e-01
Iteration	116	Cost: 1.741282e-01
Iteration	117	Cost: 1.740147e-01
Iteration	118	Cost: 1.740047e-01
Iteration	119	Cost: 1.739648e-01
Iteration	120	Cost: 1.737643e-01

Iteration	121	Cost: 1.736618e-01
Iteration	122	Cost: 1.729417e-01
Iteration	123	Cost: 1.728960e-01
Iteration	124	Cost: 1.725766e-01
Iteration	125	Cost: 1.724088e-01
Iteration	126	Cost: 1.723107e-01
Iteration	127	Cost: 1.721662e-01
Iteration	128	Cost: 1.720531e-01
Iteration	129	Cost: 1.719168e-01
Iteration	130	Cost: 1.717736e-01
Iteration	131	Cost: 1.715603e-01
Iteration	132	Cost: 1.714233e-01
Iteration	133	Cost: 1.713013e-01
Iteration	134	Cost: 1.711228e-01
Iteration	135	Cost: 1.710755e-01
Iteration	136	Cost: 1.708646e-01
Iteration	137	Cost: 1.708338e-01
Iteration	138	Cost: 1.707145e-01
Iteration	139	Cost: 1.706641e-01
Iteration	140	Cost: 1.704998e-01
Iteration	141	Cost: 1.704080e-01
Iteration	142	Cost: 1.703985e-01
Iteration	143	Cost: 1.703047e-01
Iteration	144	Cost: 1.701061e-01
Iteration	145	Cost: 1.700353e-01
Iteration	146	Cost: 1.698900e-01
Iteration	147	Cost: 1.698543e-01
Iteration	148	Cost: 1.698179e-01
Iteration	149	Cost: 1.691324e-01
Iteration	150	Cost: 1.688083e-01
Iteration	151	Cost: 1.681005e-01
Iteration	152	Cost: 1.674277e-01
Iteration	153	Cost: 1.604772e-01
Iteration	154	Cost: 1.522513e-01
Iteration	155	Cost: 1.466453e-01
Iteration	156	Cost: 1.457666e-01
Iteration	157	Cost: 1.445499e-01
Iteration	158	Cost: 1.432731e-01
Iteration	159	Cost: 1.425082e-01
Iteration	160	Cost: 1.419273e-01
Iteration	161	Cost: 1.415602e-01
Iteration	162	Cost: 1.415359e-01
Iteration	163	Cost: 1.415117e-01
Iteration	164	Cost: 1.413778e-01
Iteration	165	Cost: 1.413109e-01
Iteration	166	Cost: 1.412743e-01
Iteration	167	Cost: 1.412327e-01
Iteration	168	Cost: 1.411721e-01
Iteration	169	Cost: 1.411456e-01
Iteration	170	Cost: 1.411113e-01
Iteration	171	Cost: 1.410724e-01
Iteration	172	Cost: 1.410410e-01
Iteration	173	Cost: 1.410032e-01
Iteration	174	Cost: 1.409980e-01
Iteration	175	Cost: 1.409448e-01
Iteration	176	Cost: 1.409264e-01
Iteration	177	Cost: 1.408678e-01
Iteration	178	Cost: 1.408441e-01
Iteration	179	Cost: 1.402278e-01
Iteration	180	Cost: 1.401116e-01
Iteration	181	Cost: 1.398364e-01
Iteration	182	Cost: 1.397035e-01
Iteration	183	Cost: 1.392031e-01
Iteration	184	Cost: 1.391676e-01
Iteration	185	Cost: 1.391200e-01

Iteration	186		Cost: 1.390962e-01
Iteration	187		Cost: 1.389980e-01
Iteration	188		Cost: 1.388442e-01
Iteration	189		Cost: 1.388115e-01
Iteration	190		Cost: 1.384382e-01
Iteration	191		Cost: 1.384201e-01
Iteration	192		Cost: 1.384133e-01
Iteration	193		Cost: 1.383422e-01
Iteration	194		Cost: 1.382643e-01
Iteration	195		Cost: 1.382289e-01
Iteration	196		Cost: 1.382288e-01
Iteration	197		Cost: 1.381997e-01
Iteration	198		Cost: 1.381566e-01
Iteration	199		Cost: 1.381405e-01
Iteration	200		Cost: 1.380870e-01

10. Постройте график модели, совмещенный с обучающей выборкой, а также график процесса обучения. Какой вывод можно сделать в данном случае?

```
% Plot training data and fit
plot(X, y, 'rx', 'MarkerSize', 10, 'LineWidth', 1.5);
plotFit(min(X), max(X), mu, sigma, theta, p);
xlabel('Change in water level (x)');
ylabel('Water flowing out of the dam (y)');
title(sprintf('Polynomial Regression Fit (lambda = %f)', lambda));
```



```
[error_train, error_val] = learningCurve(X_poly, y, X_poly_val, yval, lambda);
```

Iteration	1		Cost: 3.386454e-01
Iteration	2		Cost: 0.000000e+00
Iteration	1		Cost: 5.373343e-02
Iteration	2		Cost: 2.656989e-04

Iteration	3	Cost: 1.480972e-05
Iteration	4	Cost: 1.880576e-10
Iteration	5	Cost: 1.880553e-10
Iteration	6	Cost: 9.442954e-11
Iteration	7	Cost: 6.841388e-15
Iteration	8	Cost: 6.840914e-15
Iteration	9	Cost: 3.450009e-15
Iteration	10	Cost: 1.012558e-18
Iteration	11	Cost: 1.012253e-18
Iteration	12	Cost: 4.823455e-19
Iteration	13	Cost: 4.688636e-21
Iteration	14	Cost: 2.246403e-21
Iteration	15	Cost: 1.707239e-23
Iteration	16	Cost: 8.176013e-24
Iteration	17	Cost: 6.342162e-26
Iteration	18	Cost: 3.030749e-26
Iteration	19	Cost: 2.544693e-28
Iteration	20	Cost: 1.136453e-28
Iteration	21	Cost: 6.569732e-30
Iteration	22	Cost: 3.907327e-30
Iteration	23	Cost: 2.095412e-31
Iteration	24	Cost: 1.232595e-32
Iteration	26	Cost: 0.000000e+00
Iteration	1	Cost: 3.023381e+01
Iteration	2	Cost: 9.745401e-01
Iteration	3	Cost: 4.827305e-01
Iteration	4	Cost: 1.170249e-02
Iteration	5	Cost: 9.696908e-04
Iteration	6	Cost: 5.299258e-04
Iteration	7	Cost: 1.985836e-04
Iteration	8	Cost: 6.032119e-05
Iteration	9	Cost: 6.225212e-07
Iteration	10	Cost: 3.894758e-07
Iteration	11	Cost: 7.703724e-08
Iteration	12	Cost: 5.688321e-08
Iteration	13	Cost: 5.385450e-09
Iteration	14	Cost: 1.603656e-10
Iteration	15	Cost: 1.516867e-11
Iteration	16	Cost: 9.627464e-12
Iteration	17	Cost: 2.794098e-12
Iteration	18	Cost: 7.766256e-13
Iteration	19	Cost: 1.571268e-13
Iteration	20	Cost: 2.248292e-16
Iteration	21	Cost: 5.079310e-17
Iteration	22	Cost: 1.499569e-17
Iteration	23	Cost: 3.850975e-18
Iteration	24	Cost: 1.191509e-30
Iteration	25	Cost: 1.643460e-31
Iteration	26	Cost: 6.573841e-32
Iteration	1	Cost: 7.960488e-01
Iteration	2	Cost: 2.114171e-01
Iteration	3	Cost: 2.702642e-02
Iteration	4	Cost: 3.974598e-19
Iteration	5	Cost: 3.041491e-25
Iteration	6	Cost: 1.130867e-25
Iteration	7	Cost: 3.528137e-27
Iteration	8	Cost: 6.473898e-28
Iteration	1	Cost: 9.143237e+01
Iteration	2	Cost: 3.894303e+01
Iteration	3	Cost: 1.312582e+01
Iteration	4	Cost: 5.317724e+00
Iteration	5	Cost: 1.279489e+00
Iteration	6	Cost: 6.326128e-01
Iteration	7	Cost: 3.810929e-01
Iteration	8	Cost: 1.087870e-01

Iteration	9	Cost: 8.043184e-02
Iteration	10	Cost: 6.919667e-02
Iteration	11	Cost: 5.535310e-02
Iteration	12	Cost: 5.271515e-02
Iteration	13	Cost: 4.139039e-02
Iteration	14	Cost: 3.429655e-02
Iteration	15	Cost: 3.198751e-02
Iteration	16	Cost: 2.887118e-02
Iteration	17	Cost: 2.877529e-02
Iteration	18	Cost: 2.865094e-02
Iteration	19	Cost: 2.791499e-02
Iteration	20	Cost: 2.695099e-02
Iteration	21	Cost: 2.367001e-02
Iteration	22	Cost: 2.317041e-02
Iteration	23	Cost: 2.295142e-02
Iteration	24	Cost: 2.208744e-02
Iteration	25	Cost: 2.139397e-02
Iteration	26	Cost: 2.125300e-02
Iteration	27	Cost: 1.677436e-02
Iteration	28	Cost: 1.546287e-02
Iteration	29	Cost: 1.419246e-02
Iteration	30	Cost: 1.401558e-02
Iteration	31	Cost: 1.377779e-02
Iteration	32	Cost: 1.361209e-02
Iteration	33	Cost: 1.284663e-02
Iteration	34	Cost: 1.255000e-02
Iteration	35	Cost: 1.221459e-02
Iteration	36	Cost: 1.215614e-02
Iteration	37	Cost: 1.196671e-02
Iteration	38	Cost: 1.130487e-02
Iteration	39	Cost: 1.059963e-02
Iteration	40	Cost: 1.026315e-02
Iteration	41	Cost: 1.014761e-02
Iteration	42	Cost: 9.073155e-03
Iteration	43	Cost: 8.973501e-03
Iteration	44	Cost: 8.734872e-03
Iteration	45	Cost: 8.437958e-03
Iteration	46	Cost: 8.304285e-03
Iteration	47	Cost: 8.282595e-03
Iteration	48	Cost: 7.843733e-03
Iteration	49	Cost: 7.283226e-03
Iteration	50	Cost: 7.215746e-03
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Iteration	60	Cost: 4.960723e-03
Iteration	61	Cost: 4.830965e-03
Iteration	62	Cost: 4.430419e-03
Iteration	63	Cost: 3.557900e-03
Iteration	64	Cost: 3.445714e-03
Iteration	65	Cost: 3.415359e-03
Iteration	66	Cost: 3.131083e-03
Iteration	67	Cost: 2.979556e-03
Iteration	68	Cost: 2.875317e-03
Iteration	69	Cost: 2.559780e-03
Iteration	70	Cost: 2.179121e-03
Iteration	71	Cost: 1.966495e-03
Iteration	72	Cost: 1.952690e-03
Iteration	73	Cost: 1.868806e-03

Iteration	74	Cost: 1.863362e-03
Iteration	75	Cost: 1.828073e-03
Iteration	76	Cost: 1.065294e-03
Iteration	77	Cost: 6.885630e-04
Iteration	78	Cost: 6.743171e-04
Iteration	79	Cost: 5.417633e-04
Iteration	80	Cost: 1.671882e-04
Iteration	81	Cost: 7.493893e-05
Iteration	82	Cost: 5.168664e-06
Iteration	83	Cost: 2.547263e-06
Iteration	84	Cost: 1.100118e-06
Iteration	85	Cost: 1.096112e-06
Iteration	86	Cost: 6.242611e-07
Iteration	87	Cost: 4.441987e-07
Iteration	88	Cost: 3.732962e-07
Iteration	89	Cost: 2.780994e-07
Iteration	90	Cost: 2.260469e-07
Iteration	91	Cost: 2.032634e-07
Iteration	92	Cost: 1.808890e-07
Iteration	93	Cost: 1.715859e-07
Iteration	94	Cost: 5.551309e-08
Iteration	95	Cost: 5.403699e-08
Iteration	96	Cost: 5.193721e-08
Iteration	97	Cost: 3.311046e-08
Iteration	98	Cost: 2.971065e-08
Iteration	99	Cost: 2.614489e-08
Iteration	100	Cost: 2.219439e-08
Iteration	101	Cost: 2.114010e-08
Iteration	102	Cost: 2.104211e-08
Iteration	103	Cost: 2.059396e-08
Iteration	104	Cost: 2.043283e-08
Iteration	105	Cost: 2.019289e-08
Iteration	106	Cost: 2.011212e-08
Iteration	107	Cost: 1.989895e-08
Iteration	108	Cost: 1.899870e-08
Iteration	109	Cost: 1.829393e-08
Iteration	110	Cost: 1.743524e-08
Iteration	111	Cost: 1.712221e-08
Iteration	112	Cost: 1.646645e-08
Iteration	113	Cost: 1.631614e-08
Iteration	114	Cost: 1.610357e-08
Iteration	115	Cost: 1.608503e-08
Iteration	116	Cost: 1.583519e-08
Iteration	117	Cost: 1.569334e-08
Iteration	118	Cost: 1.560448e-08
Iteration	119	Cost: 1.448802e-08
Iteration	120	Cost: 1.284705e-08
Iteration	121	Cost: 1.261531e-08
Iteration	122	Cost: 1.079611e-08
Iteration	123	Cost: 8.714038e-09
Iteration	124	Cost: 6.690051e-09
Iteration	125	Cost: 6.008779e-09
Iteration	126	Cost: 5.190931e-09
Iteration	127	Cost: 3.202698e-09
Iteration	128	Cost: 3.087555e-09
Iteration	129	Cost: 2.952169e-09
Iteration	130	Cost: 1.737350e-09
Iteration	131	Cost: 1.113668e-09
Iteration	132	Cost: 8.705194e-10
Iteration	133	Cost: 7.747150e-10
Iteration	134	Cost: 7.519241e-10
Iteration	135	Cost: 7.207160e-10
Iteration	136	Cost: 6.275562e-10
Iteration	137	Cost: 5.833423e-10
Iteration	138	Cost: 5.237283e-10

Iteration	139	Cost: 4.611953e-10
Iteration	140	Cost: 4.561720e-10
Iteration	141	Cost: 4.341269e-10
Iteration	142	Cost: 4.123599e-10
Iteration	143	Cost: 3.974397e-10
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Iteration	145	Cost: 3.320884e-10
Iteration	146	Cost: 3.079795e-10
Iteration	147	Cost: 3.009368e-10
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Iteration	149	Cost: 2.952477e-10
Iteration	150	Cost: 2.841856e-10
Iteration	151	Cost: 2.472919e-10
Iteration	152	Cost: 1.795035e-10
Iteration	153	Cost: 1.445068e-10
Iteration	154	Cost: 2.583084e-11
Iteration	155	Cost: 1.939419e-11
Iteration	156	Cost: 1.578038e-11
Iteration	157	Cost: 1.433721e-11
Iteration	158	Cost: 1.227665e-11
Iteration	159	Cost: 1.057334e-11
Iteration	160	Cost: 1.015747e-11
Iteration	161	Cost: 8.589398e-12
Iteration	162	Cost: 8.028917e-12
Iteration	163	Cost: 7.251646e-12
Iteration	164	Cost: 7.077414e-12
Iteration	165	Cost: 6.554996e-12
Iteration	166	Cost: 5.867336e-12
Iteration	167	Cost: 5.221156e-12
Iteration	168	Cost: 4.546880e-12
Iteration	169	Cost: 3.363405e-12
Iteration	170	Cost: 2.728507e-12
Iteration	171	Cost: 2.552200e-12
Iteration	172	Cost: 2.479455e-12
Iteration	173	Cost: 2.465093e-12
Iteration	174	Cost: 2.448883e-12
Iteration	175	Cost: 2.429009e-12
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Iteration	177	Cost: 2.263854e-12
Iteration	178	Cost: 1.997060e-12
Iteration	179	Cost: 1.646375e-12
Iteration	180	Cost: 1.625068e-12
Iteration	181	Cost: 1.598650e-12
Iteration	182	Cost: 1.518377e-12
Iteration	183	Cost: 1.433423e-12
Iteration	184	Cost: 1.359518e-12
Iteration	185	Cost: 1.351094e-12
Iteration	186	Cost: 1.329201e-12
Iteration	187	Cost: 1.323558e-12
Iteration	188	Cost: 1.304286e-12
Iteration	189	Cost: 1.291922e-12
Iteration	190	Cost: 1.281164e-12
Iteration	191	Cost: 1.268299e-12
Iteration	192	Cost: 1.243772e-12
Iteration	193	Cost: 1.220029e-12
Iteration	194	Cost: 1.132871e-12
Iteration	195	Cost: 1.105853e-12
Iteration	196	Cost: 1.068172e-12
Iteration	197	Cost: 1.066897e-12
Iteration	198	Cost: 1.056519e-12
Iteration	199	Cost: 1.042730e-12
Iteration	200	Cost: 1.036741e-12
Iteration	1	Cost: 6.685771e+01
Iteration	2	Cost: 1.216701e+01
Iteration	3	Cost: 1.795979e+00

Iteration	4	Cost: 6.292963e-01
Iteration	5	Cost: 2.225698e-01
Iteration	6	Cost: 5.075312e-02
Iteration	7	Cost: 4.971823e-02
Iteration	8	Cost: 4.887213e-02
Iteration	9	Cost: 4.848256e-02
Iteration	10	Cost: 4.805677e-02
Iteration	11	Cost: 4.762000e-02
Iteration	12	Cost: 4.708127e-02
Iteration	13	Cost: 4.655873e-02
Iteration	14	Cost: 4.628049e-02
Iteration	15	Cost: 4.625897e-02
Iteration	16	Cost: 4.604652e-02
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Iteration	22	Cost: 3.652888e-02
Iteration	23	Cost: 3.355242e-02
Iteration	24	Cost: 3.037904e-02
Iteration	25	Cost: 2.910642e-02
Iteration	26	Cost: 2.868376e-02
Iteration	27	Cost: 2.700317e-02
Iteration	28	Cost: 2.664259e-02
Iteration	29	Cost: 2.557185e-02
Iteration	30	Cost: 2.539219e-02
Iteration	31	Cost: 2.493349e-02
Iteration	32	Cost: 2.464371e-02
Iteration	33	Cost: 2.427607e-02
Iteration	34	Cost: 2.423805e-02
Iteration	35	Cost: 2.421838e-02
Iteration	36	Cost: 2.420185e-02
Iteration	37	Cost: 2.415470e-02
Iteration	38	Cost: 2.395153e-02
Iteration	39	Cost: 2.377304e-02
Iteration	40	Cost: 2.332665e-02
Iteration	41	Cost: 2.273707e-02
Iteration	42	Cost: 2.160424e-02
Iteration	43	Cost: 2.121597e-02
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Iteration	47	Cost: 1.761369e-02
Iteration	48	Cost: 1.746237e-02
Iteration	49	Cost: 1.726249e-02
Iteration	50	Cost: 1.723779e-02
Iteration	51	Cost: 1.712901e-02
Iteration	52	Cost: 1.704168e-02
Iteration	53	Cost: 1.674819e-02
Iteration	54	Cost: 1.672734e-02
Iteration	55	Cost: 1.669429e-02
Iteration	56	Cost: 1.666194e-02
Iteration	57	Cost: 1.664192e-02
Iteration	58	Cost: 1.662432e-02
Iteration	59	Cost: 1.645456e-02
Iteration	60	Cost: 1.641153e-02
Iteration	61	Cost: 1.635032e-02
Iteration	62	Cost: 1.633895e-02
Iteration	63	Cost: 1.630240e-02
Iteration	64	Cost: 1.621359e-02
Iteration	65	Cost: 1.615632e-02
Iteration	66	Cost: 1.611800e-02
Iteration	67	Cost: 1.602915e-02
Iteration	68	Cost: 1.593803e-02

Iteration	69	Cost: 1.588864e-02
Iteration	70	Cost: 1.584920e-02
Iteration	71	Cost: 1.564493e-02
Iteration	72	Cost: 1.556045e-02
Iteration	73	Cost: 1.552588e-02
Iteration	74	Cost: 1.548600e-02
Iteration	75	Cost: 1.538718e-02
Iteration	76	Cost: 1.525316e-02
Iteration	77	Cost: 1.495614e-02
Iteration	78	Cost: 1.481427e-02
Iteration	79	Cost: 1.475183e-02
Iteration	80	Cost: 1.467685e-02
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Iteration	84	Cost: 1.448319e-02
Iteration	85	Cost: 1.445912e-02
Iteration	86	Cost: 1.443956e-02
Iteration	87	Cost: 1.441685e-02
Iteration	88	Cost: 1.434594e-02
Iteration	89	Cost: 1.419345e-02
Iteration	90	Cost: 1.413750e-02
Iteration	91	Cost: 1.410749e-02
Iteration	92	Cost: 1.406975e-02
Iteration	93	Cost: 1.402805e-02
Iteration	94	Cost: 1.391803e-02
Iteration	95	Cost: 1.387183e-02
Iteration	96	Cost: 1.380445e-02
Iteration	97	Cost: 1.376859e-02
Iteration	98	Cost: 1.375085e-02
Iteration	99	Cost: 1.372463e-02
Iteration	100	Cost: 1.371379e-02
Iteration	101	Cost: 1.369995e-02
Iteration	102	Cost: 1.365930e-02
Iteration	103	Cost: 1.355160e-02
Iteration	104	Cost: 1.351188e-02
Iteration	105	Cost: 1.348632e-02
Iteration	106	Cost: 1.347259e-02
Iteration	107	Cost: 1.346533e-02
Iteration	108	Cost: 1.344785e-02
Iteration	109	Cost: 1.338732e-02
Iteration	110	Cost: 1.326374e-02
Iteration	111	Cost: 1.321274e-02
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Iteration	113	Cost: 1.313176e-02
Iteration	114	Cost: 1.311272e-02
Iteration	115	Cost: 1.310499e-02
Iteration	116	Cost: 1.310026e-02
Iteration	117	Cost: 1.305360e-02
Iteration	118	Cost: 1.293924e-02
Iteration	119	Cost: 1.278786e-02
Iteration	120	Cost: 1.263703e-02
Iteration	121	Cost: 1.217194e-02
Iteration	122	Cost: 1.209391e-02
Iteration	123	Cost: 1.204436e-02
Iteration	124	Cost: 1.168044e-02
Iteration	125	Cost: 1.018795e-02
Iteration	126	Cost: 9.387763e-03
Iteration	127	Cost: 9.141719e-03
Iteration	128	Cost: 8.785958e-03
Iteration	129	Cost: 8.166952e-03
Iteration	130	Cost: 8.004746e-03
Iteration	131	Cost: 7.482418e-03
Iteration	132	Cost: 6.998383e-03
Iteration	133	Cost: 6.535495e-03

Iteration	134	Cost: 6.446067e-03
Iteration	135	Cost: 6.427013e-03
Iteration	136	Cost: 6.405703e-03
Iteration	137	Cost: 6.402277e-03
Iteration	138	Cost: 6.301571e-03
Iteration	139	Cost: 6.244544e-03
Iteration	140	Cost: 6.097273e-03
Iteration	141	Cost: 6.051397e-03
Iteration	142	Cost: 5.933265e-03
Iteration	143	Cost: 5.861268e-03
Iteration	144	Cost: 5.702487e-03
Iteration	145	Cost: 5.372883e-03
Iteration	146	Cost: 5.072252e-03
Iteration	147	Cost: 4.997196e-03
Iteration	148	Cost: 4.749017e-03
Iteration	149	Cost: 4.720492e-03
Iteration	150	Cost: 4.624615e-03
Iteration	151	Cost: 4.595240e-03
Iteration	152	Cost: 4.553249e-03
Iteration	153	Cost: 4.547432e-03
Iteration	154	Cost: 4.526621e-03
Iteration	155	Cost: 4.520735e-03
Iteration	156	Cost: 4.463714e-03
Iteration	157	Cost: 4.435764e-03
Iteration	158	Cost: 4.375868e-03
Iteration	159	Cost: 4.360500e-03
Iteration	160	Cost: 4.313603e-03
Iteration	161	Cost: 4.173893e-03
Iteration	162	Cost: 3.975431e-03
Iteration	163	Cost: 3.944395e-03
Iteration	164	Cost: 3.904116e-03
Iteration	165	Cost: 3.887122e-03
Iteration	166	Cost: 3.863900e-03
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Iteration	197	Cost: 3.384254e-03
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Iteration	3	Cost: 2.533424e+00
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Iteration	5	Cost: 1.200216e+00
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Iteration	12	Cost: 5.181187e-01
Iteration	13	Cost: 4.922865e-01
Iteration	14	Cost: 4.574050e-01
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Iteration	18	Cost: 2.110339e-01
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Iteration	35	Cost: 2.978338e-01
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Iteration	39	Cost: 2.856128e-01
Iteration	40	Cost: 2.841844e-01
Iteration	41	Cost: 2.828238e-01
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Iteration	45	Cost: 2.795500e-01
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Iteration	145	Cost: 1.900004e-01
Iteration	146	Cost: 1.898915e-01
Iteration	147	Cost: 1.897874e-01
Iteration	148	Cost: 1.893543e-01
Iteration	149	Cost: 1.892775e-01
Iteration	150	Cost: 1.890038e-01
Iteration	151	Cost: 1.887483e-01
Iteration	152	Cost: 1.878496e-01
Iteration	153	Cost: 1.877733e-01
Iteration	154	Cost: 1.876688e-01
Iteration	155	Cost: 1.875669e-01
Iteration	156	Cost: 1.875549e-01
Iteration	157	Cost: 1.875472e-01
Iteration	158	Cost: 1.875159e-01
Iteration	159	Cost: 1.873801e-01
Iteration	160	Cost: 1.873338e-01
Iteration	161	Cost: 1.873258e-01
Iteration	162	Cost: 1.871687e-01
Iteration	163	Cost: 1.869943e-01
Iteration	164	Cost: 1.859488e-01
Iteration	165	Cost: 1.856430e-01
Iteration	166	Cost: 1.788313e-01
Iteration	167	Cost: 1.741272e-01
Iteration	168	Cost: 1.699817e-01
Iteration	169	Cost: 1.650535e-01
Iteration	170	Cost: 1.487253e-01
Iteration	171	Cost: 1.435087e-01
Iteration	172	Cost: 1.380910e-01
Iteration	173	Cost: 1.360013e-01

Iteration	174	Cost: 1.353665e-01
Iteration	175	Cost: 1.333614e-01
Iteration	176	Cost: 1.328515e-01
Iteration	177	Cost: 1.317057e-01
Iteration	178	Cost: 1.316045e-01
Iteration	179	Cost: 1.312103e-01
Iteration	180	Cost: 1.311435e-01
Iteration	181	Cost: 1.310734e-01
Iteration	182	Cost: 1.310144e-01
Iteration	183	Cost: 1.309781e-01
Iteration	184	Cost: 1.309576e-01
Iteration	185	Cost: 1.309506e-01
Iteration	186	Cost: 1.309364e-01
Iteration	187	Cost: 1.309203e-01
Iteration	188	Cost: 1.308617e-01
Iteration	189	Cost: 1.307131e-01
Iteration	190	Cost: 1.305336e-01
Iteration	191	Cost: 1.305048e-01
Iteration	192	Cost: 1.303804e-01
Iteration	193	Cost: 1.303565e-01
Iteration	194	Cost: 1.303261e-01
Iteration	195	Cost: 1.302594e-01
Iteration	196	Cost: 1.302209e-01
Iteration	197	Cost: 1.301430e-01
Iteration	198	Cost: 1.299397e-01
Iteration	199	Cost: 1.296795e-01
Iteration	200	Cost: 1.280960e-01
Iteration	1	Cost: 8.273077e+01
Iteration	2	Cost: 2.687496e+01
Iteration	3	Cost: 1.327780e+01
Iteration	4	Cost: 3.455324e+00
Iteration	5	Cost: 2.870493e+00
Iteration	6	Cost: 2.404364e+00
Iteration	7	Cost: 2.372779e+00
Iteration	8	Cost: 1.771555e+00
Iteration	9	Cost: 1.210317e+00
Iteration	10	Cost: 9.411245e-01
Iteration	11	Cost: 7.802115e-01
Iteration	12	Cost: 7.270456e-01
Iteration	13	Cost: 6.577683e-01
Iteration	14	Cost: 5.106861e-01
Iteration	15	Cost: 4.734015e-01
Iteration	16	Cost: 4.222337e-01
Iteration	17	Cost: 4.209566e-01
Iteration	18	Cost: 4.179436e-01
Iteration	19	Cost: 4.149038e-01
Iteration	20	Cost: 4.048243e-01
Iteration	21	Cost: 4.003634e-01
Iteration	22	Cost: 3.952067e-01
Iteration	23	Cost: 3.842805e-01
Iteration	24	Cost: 3.514872e-01
Iteration	25	Cost: 3.485057e-01
Iteration	26	Cost: 3.440929e-01
Iteration	27	Cost: 3.433698e-01
Iteration	28	Cost: 3.402403e-01
Iteration	29	Cost: 3.385564e-01
Iteration	30	Cost: 3.371135e-01
Iteration	31	Cost: 3.323856e-01
Iteration	32	Cost: 3.213089e-01
Iteration	33	Cost: 3.198552e-01
Iteration	34	Cost: 3.043161e-01
Iteration	35	Cost: 2.629876e-01
Iteration	36	Cost: 2.530939e-01
Iteration	37	Cost: 2.450565e-01
Iteration	38	Cost: 2.441580e-01

Iteration	39	Cost: 2.407571e-01
Iteration	40	Cost: 2.404626e-01
Iteration	41	Cost: 2.393662e-01
Iteration	42	Cost: 2.392498e-01
Iteration	43	Cost: 2.391169e-01
Iteration	44	Cost: 2.383570e-01
Iteration	45	Cost: 2.382119e-01
Iteration	46	Cost: 2.372786e-01
Iteration	47	Cost: 2.333841e-01
Iteration	48	Cost: 2.326425e-01
Iteration	49	Cost: 2.322579e-01
Iteration	50	Cost: 2.321067e-01
Iteration	51	Cost: 2.316359e-01
Iteration	52	Cost: 2.311190e-01
Iteration	53	Cost: 2.310144e-01
Iteration	54	Cost: 2.296767e-01
Iteration	55	Cost: 2.293098e-01
Iteration	56	Cost: 2.289738e-01
Iteration	57	Cost: 2.285946e-01
Iteration	58	Cost: 2.284382e-01
Iteration	59	Cost: 2.283791e-01
Iteration	60	Cost: 2.281269e-01
Iteration	61	Cost: 2.280692e-01
Iteration	62	Cost: 2.279445e-01
Iteration	63	Cost: 2.278727e-01
Iteration	64	Cost: 2.276174e-01
Iteration	65	Cost: 2.275821e-01
Iteration	66	Cost: 2.274535e-01
Iteration	67	Cost: 2.274175e-01
Iteration	68	Cost: 2.272772e-01
Iteration	69	Cost: 2.272474e-01
Iteration	70	Cost: 2.271243e-01
Iteration	71	Cost: 2.270930e-01
Iteration	72	Cost: 2.268701e-01
Iteration	73	Cost: 2.266744e-01
Iteration	74	Cost: 2.236910e-01
Iteration	75	Cost: 2.213602e-01
Iteration	76	Cost: 2.185692e-01
Iteration	77	Cost: 2.180727e-01
Iteration	78	Cost: 2.167949e-01
Iteration	79	Cost: 2.156531e-01
Iteration	80	Cost: 2.108199e-01
Iteration	81	Cost: 2.089561e-01
Iteration	82	Cost: 2.041837e-01
Iteration	83	Cost: 2.011422e-01
Iteration	84	Cost: 2.004799e-01
Iteration	85	Cost: 1.988686e-01
Iteration	86	Cost: 1.964732e-01
Iteration	87	Cost: 1.957600e-01
Iteration	88	Cost: 1.898125e-01
Iteration	89	Cost: 1.880149e-01
Iteration	90	Cost: 1.857863e-01
Iteration	91	Cost: 1.847378e-01
Iteration	92	Cost: 1.808871e-01
Iteration	93	Cost: 1.801229e-01
Iteration	94	Cost: 1.793317e-01
Iteration	95	Cost: 1.792268e-01
Iteration	96	Cost: 1.789535e-01
Iteration	97	Cost: 1.787999e-01
Iteration	98	Cost: 1.787706e-01
Iteration	99	Cost: 1.784343e-01
Iteration	100	Cost: 1.783865e-01
Iteration	101	Cost: 1.782204e-01
Iteration	102	Cost: 1.781227e-01
Iteration	103	Cost: 1.781045e-01

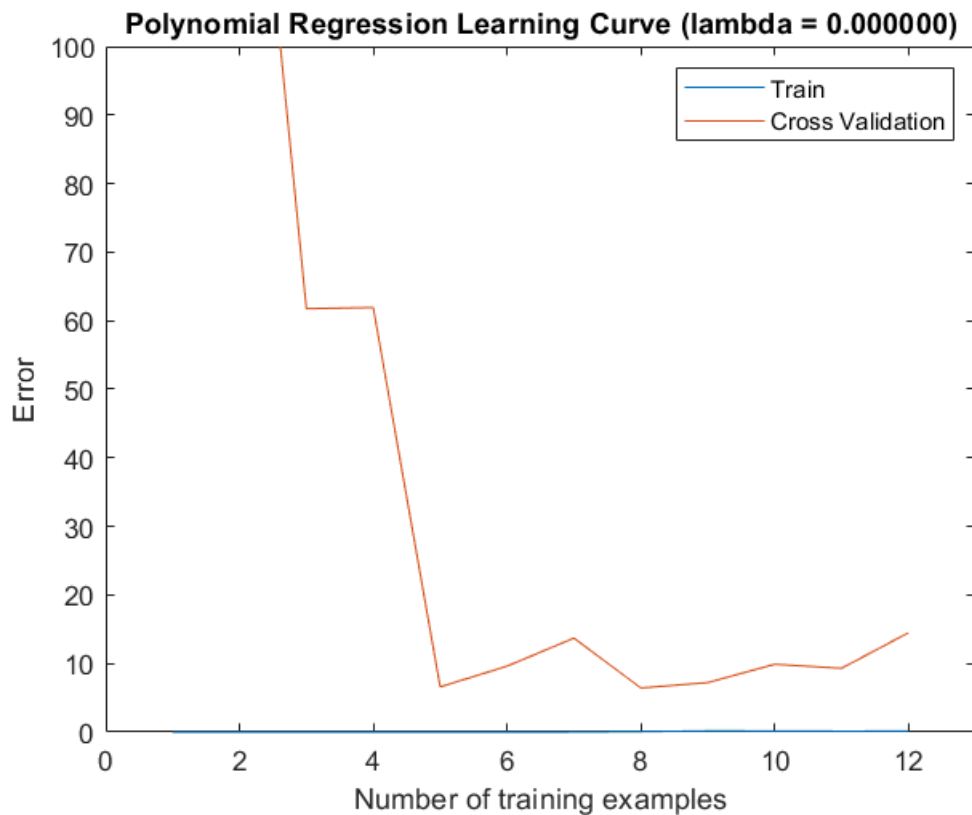
Iteration	104	Cost: 1.780330e-01
Iteration	105	Cost: 1.779761e-01
Iteration	106	Cost: 1.779575e-01
Iteration	107	Cost: 1.778883e-01
Iteration	108	Cost: 1.777697e-01
Iteration	109	Cost: 1.763832e-01
Iteration	110	Cost: 1.761266e-01
Iteration	111	Cost: 1.755509e-01
Iteration	112	Cost: 1.752843e-01
Iteration	113	Cost: 1.743353e-01
Iteration	114	Cost: 1.742830e-01
Iteration	115	Cost: 1.741572e-01
Iteration	116	Cost: 1.741282e-01
Iteration	117	Cost: 1.740147e-01
Iteration	118	Cost: 1.740047e-01
Iteration	119	Cost: 1.739648e-01
Iteration	120	Cost: 1.737643e-01
Iteration	121	Cost: 1.736618e-01
Iteration	122	Cost: 1.729417e-01
Iteration	123	Cost: 1.728960e-01
Iteration	124	Cost: 1.725766e-01
Iteration	125	Cost: 1.724088e-01
Iteration	126	Cost: 1.723107e-01
Iteration	127	Cost: 1.721662e-01
Iteration	128	Cost: 1.720531e-01
Iteration	129	Cost: 1.719168e-01
Iteration	130	Cost: 1.717736e-01
Iteration	131	Cost: 1.715603e-01
Iteration	132	Cost: 1.714233e-01
Iteration	133	Cost: 1.713013e-01
Iteration	134	Cost: 1.711228e-01
Iteration	135	Cost: 1.710755e-01
Iteration	136	Cost: 1.708646e-01
Iteration	137	Cost: 1.708338e-01
Iteration	138	Cost: 1.707145e-01
Iteration	139	Cost: 1.706641e-01
Iteration	140	Cost: 1.704998e-01
Iteration	141	Cost: 1.704080e-01
Iteration	142	Cost: 1.703985e-01
Iteration	143	Cost: 1.703047e-01
Iteration	144	Cost: 1.701061e-01
Iteration	145	Cost: 1.700353e-01
Iteration	146	Cost: 1.698900e-01
Iteration	147	Cost: 1.698543e-01
Iteration	148	Cost: 1.698179e-01
Iteration	149	Cost: 1.691324e-01
Iteration	150	Cost: 1.688083e-01
Iteration	151	Cost: 1.681005e-01
Iteration	152	Cost: 1.674277e-01
Iteration	153	Cost: 1.604772e-01
Iteration	154	Cost: 1.522513e-01
Iteration	155	Cost: 1.466453e-01
Iteration	156	Cost: 1.457666e-01
Iteration	157	Cost: 1.445499e-01
Iteration	158	Cost: 1.432731e-01
Iteration	159	Cost: 1.425082e-01
Iteration	160	Cost: 1.419273e-01
Iteration	...	

```

plot(1:m, error_train, 1:m, error_val);
title(sprintf('Polynomial Regression Learning Curve (lambda = %f)', lambda));
xlabel('Number of training examples')
ylabel('Error')
axis([0 13 0 100])

```

```
legend('Train', 'Cross Validation')
```



Ошибка на обучающей выборке низкая, но на валидационной высокая. low training error is low, but the cross validation error is high. Проблема high variance.

11. Постройте графики из пункта 10 для моделей с коэффициентами регуляризации 1 и 100. Какие выводы можно сделать?

```
lambda = 1;  
[theta] = trainLinearReg(X_poly, y, lambda);
```

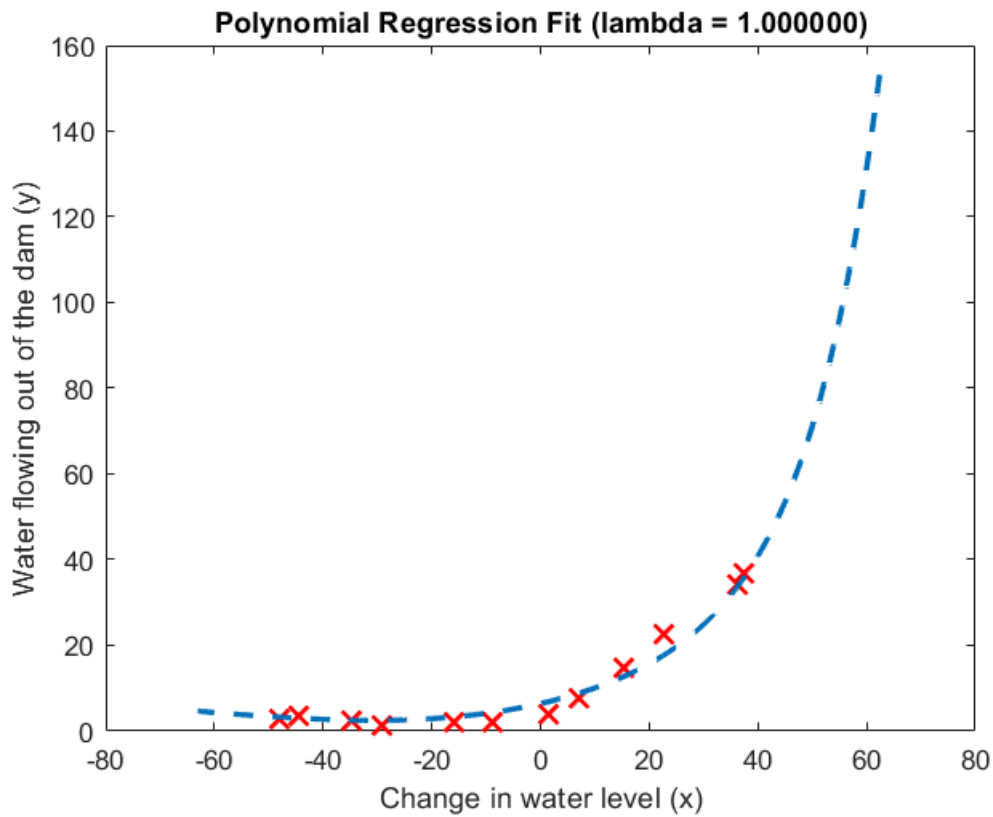
Iteration	1	Cost: 8.320954e+01
Iteration	2	Cost: 2.907694e+01
Iteration	3	Cost: 1.613078e+01
Iteration	4	Cost: 7.814702e+00
Iteration	5	Cost: 7.711843e+00
Iteration	6	Cost: 7.588232e+00
Iteration	7	Cost: 7.481019e+00
Iteration	8	Cost: 7.347791e+00
Iteration	9	Cost: 7.337625e+00
Iteration	10	Cost: 7.322456e+00
Iteration	11	Cost: 7.315629e+00
Iteration	12	Cost: 7.294256e+00
Iteration	13	Cost: 7.285757e+00
Iteration	14	Cost: 7.275676e+00
Iteration	15	Cost: 7.275194e+00
Iteration	16	Cost: 7.273592e+00
Iteration	17	Cost: 7.272031e+00
Iteration	18	Cost: 7.269888e+00
Iteration	19	Cost: 7.269128e+00

Iteration	20		Cost: 7.269033e+00
Iteration	21		Cost: 7.268309e+00
Iteration	22		Cost: 7.268211e+00
Iteration	23		Cost: 7.268192e+00
Iteration	24		Cost: 7.268151e+00
Iteration	25		Cost: 7.268150e+00
Iteration	26		Cost: 7.268149e+00
Iteration	27		Cost: 7.268148e+00
Iteration	28		Cost: 7.268148e+00
Iteration	29		Cost: 7.268148e+00
Iteration	30		Cost: 7.268148e+00
Iteration	31		Cost: 7.268148e+00
Iteration	32		Cost: 7.268148e+00
Iteration	33		Cost: 7.268148e+00
Iteration	34		Cost: 7.268148e+00
Iteration	35		Cost: 7.268148e+00
Iteration	36		Cost: 7.268148e+00
Iteration	37		Cost: 7.268148e+00
Iteration	38		Cost: 7.268148e+00
Iteration	39		Cost: 7.268148e+00
Iteration	40		Cost: 7.268148e+00
Iteration	41		Cost: 7.268148e+00
Iteration	42		Cost: 7.268148e+00
Iteration	43		Cost: 7.268148e+00
Iteration	44		Cost: 7.268148e+00
Iteration	45		Cost: 7.268148e+00
Iteration	46		Cost: 7.268148e+00
Iteration	47		Cost: 7.268148e+00
Iteration	48		Cost: 7.268148e+00
Iteration	49		Cost: 7.268148e+00
Iteration	50		Cost: 7.268148e+00
Iteration	51		Cost: 7.268148e+00
Iteration	52		Cost: 7.268148e+00
Iteration	53		Cost: 7.268148e+00
Iteration	54		Cost: 7.268148e+00

```

plot(X, y, 'rx', 'MarkerSize', 10, 'LineWidth', 1.5);
plotFit(min(X), max(X), mu, sigma, theta, p);
xlabel('Change in water level (x)');
ylabel('Water flowing out of the dam (y)');
title(sprintf('Polynomial Regression Fit (lambda = %f)', lambda));

```



```
[error_train, error_val] = learningCurve(X_poly, y, X_poly_val, yval, lambda);
```

Iteration	1	Cost: 5.280051e-01
Iteration	2	Cost: 2.083531e-01
Iteration	3	Cost: 9.810873e-02
Iteration	4	Cost: 1.501116e-03
Iteration	5	Cost: 1.089480e-03
Iteration	6	Cost: 5.204709e-31
Iteration	7	Cost: 1.745286e-31
Iteration	8	Cost: 3.643730e-32
Iteration	9	Cost: 6.001848e-33
Iteration	10	Cost: 9.121147e-34
Iteration	11	Cost: 1.855909e-62
Iteration	12	Cost: 2.113260e-65
Iteration	13	Cost: 6.814360e-71
Iteration	14	Cost: 2.197339e-76
Iteration	15	Cost: 7.085478e-82
Iteration	16	Cost: 2.284763e-87
Iteration	17	Cost: 7.367384e-93
Iteration	18	Cost: 2.375666e-98
Iteration	19	Cost: 7.660505e-104
Iteration	20	Cost: 2.470185e-109
Iteration	21	Cost: 7.965288e-115
Iteration	22	Cost: 2.568464e-120
Iteration	23	Cost: 8.282198e-126
Iteration	24	Cost: 2.670654e-131
Iteration	25	Cost: 8.611716e-137
Iteration	26	Cost: 2.776910e-142
Iteration	27	Cost: 8.954345e-148
Iteration	28	Cost: 2.887393e-153
Iteration	29	Cost: 9.310606e-159
Iteration	30	Cost: 3.002272e-164
Iteration	31	Cost: 9.681041e-170

Iteration	32	Cost: 3.121721e-175
Iteration	33	Cost: 1.006621e-180
Iteration	34	Cost: 3.245923e-186
Iteration	35	Cost: 1.046671e-191
Iteration	36	Cost: 3.375066e-197
Iteration	37	Cost: 1.088314e-202
Iteration	38	Cost: 3.509348e-208
Iteration	39	Cost: 1.131614e-213
Iteration	40	Cost: 3.648972e-219
Iteration	41	Cost: 1.176637e-224
Iteration	42	Cost: 3.794151e-230
Iteration	43	Cost: 1.223451e-235
Iteration	44	Cost: 3.945107e-241
Iteration	45	Cost: 1.272128e-246
Iteration	46	Cost: 4.102068e-252
Iteration	47	Cost: 1.322741e-257
Iteration	48	Cost: 4.265274e-263
Iteration	49	Cost: 1.375368e-268
Iteration	50	Cost: 4.434974e-274
Iteration	51	Cost: 1.430089e-279
Iteration	52	Cost: 4.611425e-285
Iteration	53	Cost: 1.486987e-290
Iteration	54	Cost: 4.794897e-296
Iteration	55	Cost: 1.546149e-301
Iteration	56	Cost: 4.985669e-307
Iteration	57	Cost: 1.607665e-312
Iteration	58	Cost: 0.000000e+00
Iteration	1	Cost: 2.032751e-01
Iteration	2	Cost: 1.041953e-01
Iteration	3	Cost: 7.367762e-02
Iteration	4	Cost: 7.279642e-02
Iteration	5	Cost: 7.269797e-02
Iteration	6	Cost: 7.269533e-02
Iteration	7	Cost: 7.269502e-02
Iteration	8	Cost: 7.269437e-02
Iteration	9	Cost: 7.269436e-02
Iteration	10	Cost: 7.269436e-02
Iteration	11	Cost: 7.269436e-02
Iteration	12	Cost: 7.269436e-02
Iteration	13	Cost: 7.269436e-02
Iteration	14	Cost: 7.269436e-02
Iteration	15	Cost: 7.269436e-02
Iteration	16	Cost: 7.269436e-02
Iteration	17	Cost: 7.269436e-02
Iteration	18	Cost: 7.269436e-02
Iteration	19	Cost: 7.269436e-02
Iteration	20	Cost: 7.269436e-02
Iteration	1	Cost: 3.958682e+01
Iteration	2	Cost: 2.172738e+01
Iteration	3	Cost: 2.007128e+01
Iteration	4	Cost: 1.908475e+01
Iteration	5	Cost: 1.903782e+01
Iteration	6	Cost: 1.872107e+01
Iteration	7	Cost: 1.855211e+01
Iteration	8	Cost: 1.852112e+01
Iteration	9	Cost: 1.850029e+01
Iteration	10	Cost: 1.849891e+01
Iteration	11	Cost: 1.849887e+01
Iteration	12	Cost: 1.849879e+01
Iteration	13	Cost: 1.849879e+01
Iteration	14	Cost: 1.849879e+01
Iteration	15	Cost: 1.849879e+01
Iteration	16	Cost: 1.849879e+01
Iteration	17	Cost: 1.849879e+01
Iteration	18	Cost: 1.849879e+01

Iteration	19	Cost: 1.849879e+01
Iteration	20	Cost: 1.849879e+01
Iteration	21	Cost: 1.849879e+01
Iteration	22	Cost: 1.849879e+01
Iteration	23	Cost: 1.849879e+01
Iteration	24	Cost: 1.849879e+01
Iteration	1	Cost: 1.883439e+01
Iteration	2	Cost: 1.695119e+01
Iteration	3	Cost: 1.546680e+01
Iteration	4	Cost: 1.486258e+01
Iteration	5	Cost: 1.462699e+01
Iteration	6	Cost: 1.460173e+01
Iteration	7	Cost: 1.458789e+01
Iteration	8	Cost: 1.458160e+01
Iteration	9	Cost: 1.457865e+01
Iteration	10	Cost: 1.457607e+01
Iteration	11	Cost: 1.457597e+01
Iteration	12	Cost: 1.457592e+01
Iteration	13	Cost: 1.457591e+01
Iteration	14	Cost: 1.457588e+01
Iteration	15	Cost: 1.457587e+01
Iteration	16	Cost: 1.457586e+01
Iteration	17	Cost: 1.457586e+01
Iteration	18	Cost: 1.457586e+01
Iteration	19	Cost: 1.457586e+01
Iteration	20	Cost: 1.457586e+01
Iteration	21	Cost: 1.457586e+01
Iteration	22	Cost: 1.457586e+01
Iteration	23	Cost: 1.457586e+01
Iteration	24	Cost: 1.457586e+01
Iteration	25	Cost: 1.457586e+01
Iteration	26	Cost: 1.457586e+01
Iteration	27	Cost: 1.457586e+01
Iteration	28	Cost: 1.457586e+01
Iteration	29	Cost: 1.457586e+01
Iteration	30	Cost: 1.457586e+01
Iteration	31	Cost: 1.457586e+01
Iteration	32	Cost: 1.457586e+01
Iteration	33	Cost: 1.457586e+01
Iteration	34	Cost: 1.457586e+01
Iteration	35	Cost: 1.457586e+01
Iteration	36	Cost: 1.457586e+01
Iteration	1	Cost: 9.507932e+01
Iteration	2	Cost: 3.745281e+01
Iteration	3	Cost: 1.603853e+01
Iteration	4	Cost: 1.259101e+01
Iteration	5	Cost: 1.224802e+01
Iteration	6	Cost: 1.203684e+01
Iteration	7	Cost: 1.177030e+01
Iteration	8	Cost: 1.170386e+01
Iteration	9	Cost: 1.167452e+01
Iteration	10	Cost: 1.166570e+01
Iteration	11	Cost: 1.166402e+01
Iteration	12	Cost: 1.166161e+01
Iteration	13	Cost: 1.166152e+01
Iteration	14	Cost: 1.166128e+01
Iteration	15	Cost: 1.166104e+01
Iteration	16	Cost: 1.166089e+01
Iteration	17	Cost: 1.166088e+01
Iteration	18	Cost: 1.166083e+01
Iteration	19	Cost: 1.166073e+01
Iteration	20	Cost: 1.166072e+01
Iteration	21	Cost: 1.166072e+01
Iteration	22	Cost: 1.166072e+01
Iteration	23	Cost: 1.166072e+01

Iteration	24	Cost: 1.166072e+01
Iteration	25	Cost: 1.166072e+01
Iteration	26	Cost: 1.166072e+01
Iteration	27	Cost: 1.166072e+01
Iteration	28	Cost: 1.166072e+01
Iteration	29	Cost: 1.166072e+01
Iteration	30	Cost: 1.166072e+01
Iteration	31	Cost: 1.166072e+01
Iteration	32	Cost: 1.166072e+01
Iteration	33	Cost: 1.166072e+01
Iteration	34	Cost: 1.166072e+01
Iteration	35	Cost: 1.166072e+01
Iteration	36	Cost: 1.166072e+01
Iteration	37	Cost: 1.166072e+01
Iteration	38	Cost: 1.166072e+01
Iteration	39	Cost: 1.166072e+01
Iteration	40	Cost: 1.166072e+01
Iteration	41	Cost: 1.166072e+01
Iteration	42	Cost: 1.166072e+01
Iteration	43	Cost: 1.166072e+01
Iteration	44	Cost: 1.166072e+01
Iteration	45	Cost: 1.166072e+01
Iteration	46	Cost: 1.166072e+01
Iteration	47	Cost: 1.166072e+01
Iteration	48	Cost: 1.166072e+01
Iteration	49	Cost: 1.166072e+01
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Iteration	6	Cost: 1.034120e+01
Iteration	7	Cost: 1.026977e+01
Iteration	8	Cost: 1.022714e+01
Iteration	9	Cost: 1.019759e+01
Iteration	10	Cost: 1.015385e+01
Iteration	11	Cost: 1.014049e+01
Iteration	12	Cost: 1.013163e+01
Iteration	13	Cost: 1.013124e+01
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Iteration	15	Cost: 1.012593e+01
Iteration	16	Cost: 1.011958e+01
Iteration	17	Cost: 1.011929e+01
Iteration	18	Cost: 1.011892e+01
Iteration	19	Cost: 1.011888e+01
Iteration	20	Cost: 1.011885e+01
Iteration	21	Cost: 1.011883e+01
Iteration	22	Cost: 1.011882e+01
Iteration	23	Cost: 1.011882e+01
Iteration	24	Cost: 1.011882e+01
Iteration	25	Cost: 1.011882e+01
Iteration	26	Cost: 1.011882e+01
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Iteration	29	Cost: 1.011882e+01

Iteration	30	Cost: 1.011882e+01
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Iteration	42	Cost: 1.011882e+01
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Iteration	51	Cost: 1.011882e+01
Iteration	52	Cost: 1.011882e+01
Iteration	53	Cost: 1.011882e+01
Iteration	54	Cost: 1.011882e+01
Iteration	55	Cost: 1.011882e+01
Iteration	56	Cost: 1.011882e+01
Iteration	57	Cost: 1.011882e+01
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Iteration	38	Cost: 9.416317e+00
Iteration	39	Cost: 9.416317e+00
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Iteration	6	Cost: 8.525026e+00
Iteration	7	Cost: 8.438127e+00
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Iteration	9	Cost: 8.306442e+00
Iteration	10	Cost: 8.284594e+00
Iteration	11	Cost: 8.274856e+00
Iteration	12	Cost: 8.261272e+00
Iteration	13	Cost: 8.260765e+00
Iteration	14	Cost: 8.258593e+00
Iteration	15	Cost: 8.258095e+00
Iteration	16	Cost: 8.257442e+00
Iteration	17	Cost: 8.257224e+00
Iteration	18	Cost: 8.257034e+00
Iteration	19	Cost: 8.256780e+00
Iteration	20	Cost: 8.256332e+00
Iteration	21	Cost: 8.256294e+00
Iteration	22	Cost: 8.256256e+00
Iteration	23	Cost: 8.256244e+00

Iteration	24	Cost: 8.256230e+00
Iteration	25	Cost: 8.256229e+00
Iteration	26	Cost: 8.256227e+00
Iteration	27	Cost: 8.256226e+00
Iteration	28	Cost: 8.256225e+00
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Iteration	2	Cost: 1.233951e+01
Iteration	3	Cost: 1.172055e+01
Iteration	4	Cost: 9.221113e+00
Iteration	5	Cost: 8.122554e+00
Iteration	6	Cost: 7.932984e+00
Iteration	7	Cost: 7.313700e+00
Iteration	8	Cost: 7.210498e+00
Iteration	9	Cost: 7.185608e+00
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Iteration	36	Cost: 6.423784e+00
Iteration	37	Cost: 6.423784e+00
Iteration	38	Cost: 6.423784e+00
Iteration	39	Cost: 6.423784e+00

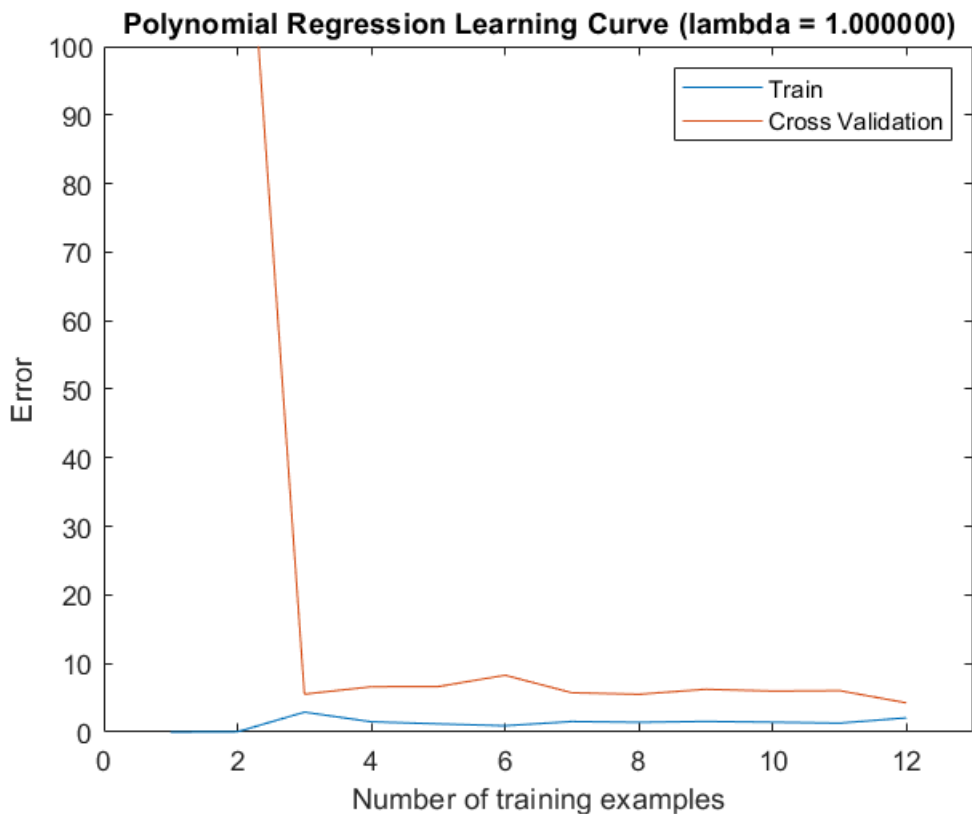
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Iteration	65	Cost: 6.423784e+00
Iteration	66	Cost: 6.423784e+00
Iteration	67	Cost: 6.423784e+00
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Iteration	2	Cost: 2.907694e+01
Iteration	3	Cost: 1.613078e+01
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Iteration	7	Cost: 7.481019e+00
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Iteration	9	Cost: 7.337625e+00
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Iteration	14	Cost: 7.275676e+00
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Iteration	37	Cost: 7.268148e+00
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Iteration	49	Cost: 7.268148e+00
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Iteration	51	Cost: 7.268148e+00
Iteration	52	Cost: 7.268148e+00
Iteration	53	Cost: 7.268148e+00
Iteration	54	Cost: 7.268148e+00

```

plot(1:m, error_train, 1:m, error_val);
title(sprintf('Polynomial Regression Learning Curve (lambda = %f)', lambda));
xlabel('Number of training examples')
ylabel('Error')
axis([0 13 0 100])
legend('Train', 'Cross Validation')

```



```

lambda = 100;
[theta] = trainLinearReg(X_poly, y, lambda);

```

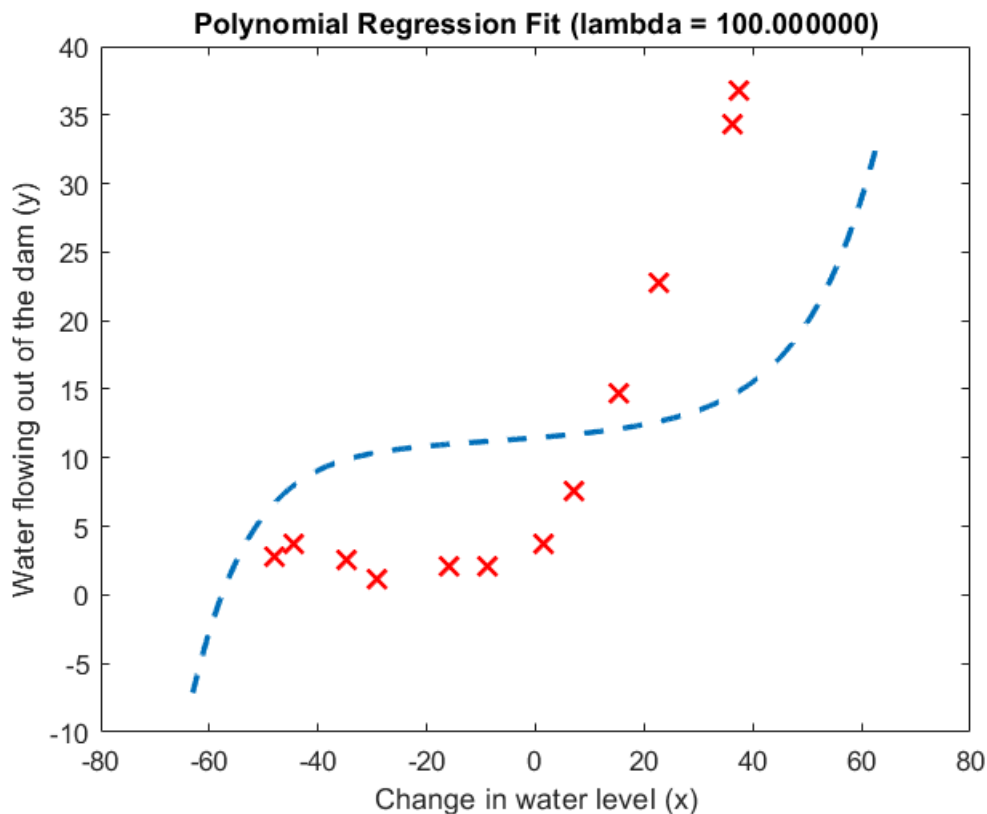
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Iteration	2	Cost: 8.964311e+01
Iteration	3	Cost: 7.339016e+01

Iteration	4	Cost: 7.283318e+01
Iteration	5	Cost: 6.732411e+01
Iteration	6	Cost: 6.676558e+01
Iteration	7	Cost: 6.673472e+01
Iteration	8	Cost: 6.673391e+01
Iteration	9	Cost: 6.673354e+01
Iteration	10	Cost: 6.673329e+01
Iteration	11	Cost: 6.673322e+01
Iteration	12	Cost: 6.673317e+01
Iteration	13	Cost: 6.673317e+01
Iteration	14	Cost: 6.673316e+01
Iteration	15	Cost: 6.673316e+01
Iteration	16	Cost: 6.673316e+01
Iteration	17	Cost: 6.673316e+01
Iteration	18	Cost: 6.673316e+01
Iteration	19	Cost: 6.673316e+01
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Iteration	23	Cost: 6.673316e+01
Iteration	25	Cost: 6.673316e+01
Iteration	26	Cost: 6.673316e+01
Iteration	27	Cost: 6.673316e+01

```

plot(X, y, 'rx', 'MarkerSize', 10, 'LineWidth', 1.5);
plotFit(min(X), max(X), mu, sigma, theta, p);
xlabel('Change in water level (x)');
ylabel('Water flowing out of the dam (y)');
title (sprintf('Polynomial Regression Fit (lambda = %f)', lambda));

```



```

[error_train, error_val] = learningCurve(X_poly, y, X_poly_val, yval, lambda);

```

Iteration	1	Cost: 2.178715e+00
-----------	---	--------------------

Iteration	2	Cost: 2.980435e-28
Iteration	3	Cost: 2.828519e-28
Iteration	4	Cost: 2.440717e-29
Iteration	5	Cost: 2.313706e-29
Iteration	6	Cost: 1.219265e-29
Iteration	7	Cost: 7.885077e-30
Iteration	8	Cost: 6.076818e-30
Iteration	9	Cost: 9.145285e-31
Iteration	10	Cost: 5.814052e-31
Iteration	11	Cost: 4.149827e-31
Iteration	12	Cost: 1.805734e-31
Iteration	13	Cost: 9.904110e-32
Iteration	15	Cost: 9.862155e-32
Iteration	1	Cost: 1.377219e+00
Iteration	2	Cost: 1.913835e-01
Iteration	3	Cost: 1.909083e-01
Iteration	4	Cost: 1.574826e-01
Iteration	5	Cost: 1.167971e-01
Iteration	6	Cost: 1.167255e-01
Iteration	7	Cost: 1.160132e-01
Iteration	8	Cost: 1.151354e-01
Iteration	9	Cost: 1.149515e-01
Iteration	10	Cost: 1.148641e-01
Iteration	11	Cost: 1.147780e-01
Iteration	12	Cost: 1.147779e-01
Iteration	13	Cost: 1.147779e-01
Iteration	14	Cost: 1.147779e-01
Iteration	15	Cost: 1.147779e-01
Iteration	16	Cost: 1.147779e-01
Iteration	17	Cost: 1.147779e-01
Iteration	18	Cost: 1.147779e-01
Iteration	19	Cost: 1.147779e-01
Iteration	20	Cost: 1.147779e-01
Iteration	21	Cost: 1.147779e-01
Iteration	22	Cost: 1.147779e-01
Iteration	23	Cost: 1.147779e-01
Iteration	24	Cost: 1.147779e-01
Iteration	25	Cost: 1.147779e-01
Iteration	1	Cost: 1.832536e+02
Iteration	2	Cost: 1.261509e+02
Iteration	3	Cost: 1.245625e+02
Iteration	4	Cost: 1.132056e+02
Iteration	5	Cost: 1.127825e+02
Iteration	6	Cost: 1.127823e+02
Iteration	7	Cost: 1.127823e+02
Iteration	8	Cost: 1.127823e+02
Iteration	9	Cost: 1.127823e+02
Iteration	10	Cost: 1.127823e+02
Iteration	11	Cost: 1.127823e+02
Iteration	12	Cost: 1.127823e+02
Iteration	13	Cost: 1.127823e+02
Iteration	14	Cost: 1.127823e+02
Iteration	15	Cost: 1.127823e+02
Iteration	16	Cost: 1.127823e+02
Iteration	17	Cost: 1.127823e+02
Iteration	18	Cost: 1.127823e+02
Iteration	20	Cost: 1.127823e+02
Iteration	21	Cost: 1.127823e+02
Iteration	22	Cost: 1.127823e+02
Iteration	1	Cost: 2.733059e+02
Iteration	2	Cost: 1.372421e+02
Iteration	3	Cost: 1.346771e+02
Iteration	4	Cost: 1.335349e+02
Iteration	5	Cost: 1.326975e+02
Iteration	6	Cost: 1.326966e+02

Iteration	7	Cost: 1.326525e+02
Iteration	8	Cost: 1.326430e+02
Iteration	9	Cost: 1.326354e+02
Iteration	10	Cost: 1.326237e+02
Iteration	11	Cost: 1.326207e+02
Iteration	12	Cost: 1.326204e+02
Iteration	13	Cost: 1.326203e+02
Iteration	14	Cost: 1.326203e+02
Iteration	15	Cost: 1.326203e+02
Iteration	16	Cost: 1.326203e+02
Iteration	17	Cost: 1.326203e+02
Iteration	18	Cost: 1.326203e+02
Iteration	19	Cost: 1.326203e+02
Iteration	20	Cost: 1.326203e+02
Iteration	21	Cost: 1.326203e+02
Iteration	22	Cost: 1.326203e+02
Iteration	23	Cost: 1.326203e+02
Iteration	24	Cost: 1.326203e+02
Iteration	25	Cost: 1.326203e+02
Iteration	26	Cost: 1.326203e+02
Iteration	27	Cost: 1.326203e+02
Iteration	1	Cost: 2.219277e+02
Iteration	2	Cost: 1.869369e+02
Iteration	3	Cost: 1.182851e+02
Iteration	4	Cost: 1.173776e+02
Iteration	5	Cost: 1.173495e+02
Iteration	6	Cost: 1.173493e+02
Iteration	7	Cost: 1.173493e+02
Iteration	8	Cost: 1.173492e+02
Iteration	9	Cost: 1.173492e+02
Iteration	10	Cost: 1.173491e+02
Iteration	11	Cost: 1.173491e+02
Iteration	12	Cost: 1.173491e+02
Iteration	13	Cost: 1.173491e+02
Iteration	14	Cost: 1.173491e+02
Iteration	15	Cost: 1.173491e+02
Iteration	16	Cost: 1.173491e+02
Iteration	17	Cost: 1.173491e+02
Iteration	18	Cost: 1.173491e+02
Iteration	19	Cost: 1.173491e+02
Iteration	20	Cost: 1.173491e+02
Iteration	21	Cost: 1.173491e+02
Iteration	22	Cost: 1.173491e+02
Iteration	23	Cost: 1.173491e+02
Iteration	24	Cost: 1.173491e+02
Iteration	25	Cost: 1.173491e+02
Iteration	26	Cost: 1.173491e+02
Iteration	27	Cost: 1.173491e+02
Iteration	28	Cost: 1.173491e+02
Iteration	1	Cost: 1.849990e+02
Iteration	2	Cost: 1.558036e+02
Iteration	3	Cost: 1.170396e+02
Iteration	4	Cost: 1.169578e+02
Iteration	5	Cost: 1.151019e+02
Iteration	6	Cost: 1.124929e+02
Iteration	7	Cost: 1.114802e+02
Iteration	8	Cost: 1.114708e+02
Iteration	9	Cost: 1.105096e+02
Iteration	10	Cost: 1.102867e+02
Iteration	11	Cost: 1.101409e+02
Iteration	12	Cost: 1.100833e+02
Iteration	13	Cost: 1.099535e+02
Iteration	14	Cost: 1.099417e+02
Iteration	15	Cost: 1.099341e+02
Iteration	16	Cost: 1.099248e+02

Iteration	17	Cost: 1.099236e+02
Iteration	18	Cost: 1.099225e+02
Iteration	19	Cost: 1.099215e+02
Iteration	20	Cost: 1.099214e+02
Iteration	21	Cost: 1.099214e+02
Iteration	22	Cost: 1.099213e+02
Iteration	23	Cost: 1.099213e+02
Iteration	24	Cost: 1.099213e+02
Iteration	25	Cost: 1.099213e+02
Iteration	26	Cost: 1.099213e+02
Iteration	27	Cost: 1.099213e+02
Iteration	28	Cost: 1.099213e+02
Iteration	29	Cost: 1.099213e+02
Iteration	30	Cost: 1.099213e+02
Iteration	31	Cost: 1.099213e+02
Iteration	32	Cost: 1.099213e+02
Iteration	33	Cost: 1.099213e+02
Iteration	34	Cost: 1.099213e+02
Iteration	35	Cost: 1.099213e+02
Iteration	36	Cost: 1.099213e+02
Iteration	37	Cost: 1.099213e+02
Iteration	38	Cost: 1.099213e+02
Iteration	39	Cost: 1.099213e+02
Iteration	40	Cost: 1.099213e+02
Iteration	41	Cost: 1.099213e+02
Iteration	42	Cost: 1.099213e+02
Iteration	43	Cost: 1.099213e+02
Iteration	45	Cost: 1.099213e+02
Iteration	1	Cost: 1.700592e+02
Iteration	2	Cost: 1.377894e+02
Iteration	3	Cost: 1.016360e+02
Iteration	4	Cost: 9.661395e+01
Iteration	5	Cost: 9.453521e+01
Iteration	6	Cost: 9.440758e+01
Iteration	7	Cost: 9.435662e+01
Iteration	8	Cost: 9.432305e+01
Iteration	9	Cost: 9.429289e+01
Iteration	10	Cost: 9.428307e+01
Iteration	11	Cost: 9.427915e+01
Iteration	12	Cost: 9.427892e+01
Iteration	13	Cost: 9.427879e+01
Iteration	14	Cost: 9.427861e+01
Iteration	15	Cost: 9.427858e+01
Iteration	16	Cost: 9.427854e+01
Iteration	17	Cost: 9.427851e+01
Iteration	18	Cost: 9.427848e+01
Iteration	19	Cost: 9.427848e+01
Iteration	20	Cost: 9.427848e+01
Iteration	21	Cost: 9.427848e+01
Iteration	22	Cost: 9.427848e+01
Iteration	23	Cost: 9.427848e+01
Iteration	24	Cost: 9.427848e+01
Iteration	25	Cost: 9.427848e+01
Iteration	26	Cost: 9.427848e+01
Iteration	27	Cost: 9.427848e+01
Iteration	28	Cost: 9.427848e+01
Iteration	29	Cost: 9.427848e+01
Iteration	1	Cost: 1.540955e+02
Iteration	2	Cost: 1.230430e+02
Iteration	3	Cost: 9.101466e+01
Iteration	4	Cost: 8.846155e+01
Iteration	5	Cost: 8.769538e+01
Iteration	6	Cost: 8.732215e+01
Iteration	7	Cost: 8.732026e+01
Iteration	8	Cost: 8.731929e+01

Iteration	9	Cost: 8.731907e+01
Iteration	10	Cost: 8.731906e+01
Iteration	11	Cost: 8.731906e+01
Iteration	12	Cost: 8.731906e+01
Iteration	13	Cost: 8.731906e+01
Iteration	14	Cost: 8.731906e+01
Iteration	16	Cost: 8.731906e+01
Iteration	17	Cost: 8.731906e+01
Iteration	18	Cost: 8.731906e+01
Iteration	1	Cost: 1.362770e+02
Iteration	2	Cost: 1.062235e+02
Iteration	3	Cost: 8.609139e+01
Iteration	4	Cost: 8.501865e+01
Iteration	5	Cost: 8.136361e+01
Iteration	6	Cost: 8.130367e+01
Iteration	7	Cost: 8.124464e+01
Iteration	8	Cost: 8.109719e+01
Iteration	9	Cost: 8.108493e+01
Iteration	10	Cost: 8.108476e+01
Iteration	11	Cost: 8.108433e+01
Iteration	12	Cost: 8.108433e+01
Iteration	13	Cost: 8.108431e+01
Iteration	14	Cost: 8.108431e+01
Iteration	15	Cost: 8.108431e+01
Iteration	16	Cost: 8.108431e+01
Iteration	17	Cost: 8.108431e+01
Iteration	18	Cost: 8.108431e+01
Iteration	19	Cost: 8.108431e+01
Iteration	20	Cost: 8.108431e+01
Iteration	21	Cost: 8.108431e+01
Iteration	22	Cost: 8.108431e+01
Iteration	23	Cost: 8.108431e+01
Iteration	24	Cost: 8.108431e+01
Iteration	1	Cost: 1.224596e+02
Iteration	2	Cost: 1.033557e+02
Iteration	3	Cost: 8.856048e+01
Iteration	4	Cost: 7.515587e+01
Iteration	5	Cost: 7.397308e+01
Iteration	6	Cost: 7.393715e+01
Iteration	7	Cost: 7.391573e+01
Iteration	8	Cost: 7.391566e+01
Iteration	9	Cost: 7.391557e+01
Iteration	10	Cost: 7.391556e+01
Iteration	11	Cost: 7.391555e+01
Iteration	12	Cost: 7.391554e+01
Iteration	13	Cost: 7.391554e+01
Iteration	14	Cost: 7.391554e+01
Iteration	15	Cost: 7.391554e+01
Iteration	16	Cost: 7.391554e+01
Iteration	17	Cost: 7.391554e+01
Iteration	18	Cost: 7.391554e+01
Iteration	19	Cost: 7.391554e+01
Iteration	20	Cost: 7.391554e+01
Iteration	21	Cost: 7.391554e+01
Iteration	22	Cost: 7.391554e+01
Iteration	23	Cost: 7.391554e+01
Iteration	24	Cost: 7.391554e+01
Iteration	25	Cost: 7.391554e+01
Iteration	26	Cost: 7.391554e+01
Iteration	27	Cost: 7.391554e+01
Iteration	28	Cost: 7.391554e+01
Iteration	29	Cost: 7.391554e+01
Iteration	30	Cost: 7.391554e+01
Iteration	32	Cost: 7.391554e+01
Iteration	34	Cost: 7.391554e+01

Iteration	35	Cost: 7.391554e+01
Iteration	37	Cost: 7.391554e+01
Iteration	38	Cost: 7.391554e+01
Iteration	40	Cost: 7.391554e+01
Iteration	1	Cost: 1.126591e+02
Iteration	2	Cost: 9.388083e+01
Iteration	3	Cost: 7.910290e+01
Iteration	4	Cost: 6.933871e+01
Iteration	5	Cost: 6.891428e+01
Iteration	6	Cost: 6.804009e+01
Iteration	7	Cost: 6.783782e+01
Iteration	8	Cost: 6.770419e+01
Iteration	9	Cost: 6.767548e+01
Iteration	10	Cost: 6.766408e+01
Iteration	11	Cost: 6.766157e+01
Iteration	12	Cost: 6.765950e+01
Iteration	13	Cost: 6.765850e+01
Iteration	14	Cost: 6.765807e+01
Iteration	15	Cost: 6.765807e+01
Iteration	16	Cost: 6.765806e+01
Iteration	17	Cost: 6.765806e+01
Iteration	18	Cost: 6.765806e+01
Iteration	19	Cost: 6.765806e+01
Iteration	20	Cost: 6.765806e+01
Iteration	21	Cost: 6.765806e+01
Iteration	22	Cost: 6.765806e+01
Iteration	23	Cost: 6.765806e+01
Iteration	24	Cost: 6.765806e+01
Iteration	25	Cost: 6.765806e+01
Iteration	26	Cost: 6.765806e+01
Iteration	28	Cost: 6.765806e+01
Iteration	29	Cost: 6.765806e+01
Iteration	1	Cost: 1.218518e+02
Iteration	2	Cost: 8.964311e+01
Iteration	3	Cost: 7.339016e+01
Iteration	4	Cost: 7.283318e+01
Iteration	5	Cost: 6.732411e+01
Iteration	6	Cost: 6.676558e+01
Iteration	7	Cost: 6.673472e+01
Iteration	8	Cost: 6.673391e+01
Iteration	9	Cost: 6.673354e+01
Iteration	10	Cost: 6.673329e+01
Iteration	11	Cost: 6.673322e+01
Iteration	12	Cost: 6.673317e+01
Iteration	13	Cost: 6.673317e+01
Iteration	14	Cost: 6.673316e+01
Iteration	15	Cost: 6.673316e+01
Iteration	16	Cost: 6.673316e+01
Iteration	17	Cost: 6.673316e+01
Iteration	18	Cost: 6.673316e+01
Iteration	19	Cost: 6.673316e+01
Iteration	20	Cost: 6.673316e+01
Iteration	21	Cost: 6.673316e+01
Iteration	22	Cost: 6.673316e+01
Iteration	23	Cost: 6.673316e+01
Iteration	25	Cost: 6.673316e+01
Iteration	26	Cost: 6.673316e+01
Iteration	27	Cost: 6.673316e+01

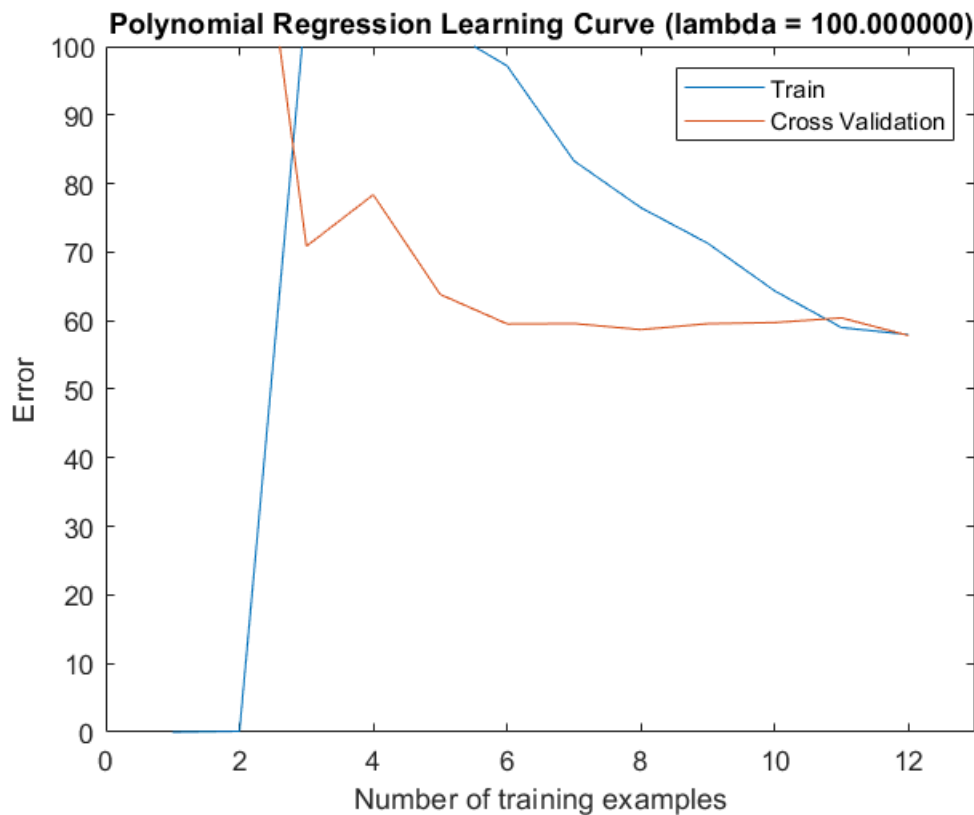
```

plot(1:m, error_train, 1:m, error_val);
title(sprintf('Polynomial Regression Learning Curve (lambda = %f)', lambda));
xlabel('Number of training examples')
ylabel('Error')
axis([0 13 0 100])

```



```
legend('Train', 'Cross Validation')
```



Lambda = 1 показал хорошие результаты, Lambda = 100 - слишком большой коэффициент, не подстроилось под данные.

12. С помощью валидационной выборки подберите коэффициент регуляризации, который позволяет достичь наименьшей ошибки. Процесс подбора отразите с помощью графика (графиков).

```
[lambda_vec, error_train, error_val] = validationCurve(X_poly, y, X_poly_val, yval);
```

Iteration	1		Cost: 8.273077e+01
Iteration	2		Cost: 2.687496e+01
Iteration	3		Cost: 1.327780e+01
Iteration	4		Cost: 3.455324e+00
Iteration	5		Cost: 2.870493e+00
Iteration	6		Cost: 2.404364e+00
Iteration	7		Cost: 2.372779e+00
Iteration	8		Cost: 1.771555e+00
Iteration	9		Cost: 1.210317e+00
Iteration	10		Cost: 9.411245e-01
Iteration	11		Cost: 7.802115e-01
Iteration	12		Cost: 7.270456e-01
Iteration	13		Cost: 6.577683e-01
Iteration	14		Cost: 5.106861e-01
Iteration	15		Cost: 4.734015e-01
Iteration	16		Cost: 4.222337e-01
Iteration	17		Cost: 4.209566e-01
Iteration	18		Cost: 4.179436e-01
Iteration	19		Cost: 4.149038e-01
Iteration	20		Cost: 4.048243e-01
Iteration	21		Cost: 4.003634e-01

Iteration	22	Cost: 3.952067e-01
Iteration	23	Cost: 3.842805e-01
Iteration	24	Cost: 3.514872e-01
Iteration	25	Cost: 3.485057e-01
Iteration	26	Cost: 3.440929e-01
Iteration	27	Cost: 3.433698e-01
Iteration	28	Cost: 3.402403e-01
Iteration	29	Cost: 3.385564e-01
Iteration	30	Cost: 3.371135e-01
Iteration	31	Cost: 3.323856e-01
Iteration	32	Cost: 3.213089e-01
Iteration	33	Cost: 3.198552e-01
Iteration	34	Cost: 3.043161e-01
Iteration	35	Cost: 2.629876e-01
Iteration	36	Cost: 2.530939e-01
Iteration	37	Cost: 2.450565e-01
Iteration	38	Cost: 2.441580e-01
Iteration	39	Cost: 2.407571e-01
Iteration	40	Cost: 2.404626e-01
Iteration	41	Cost: 2.393662e-01
Iteration	42	Cost: 2.392498e-01
Iteration	43	Cost: 2.391169e-01
Iteration	44	Cost: 2.383570e-01
Iteration	45	Cost: 2.382119e-01
Iteration	46	Cost: 2.372786e-01
Iteration	47	Cost: 2.333841e-01
Iteration	48	Cost: 2.326425e-01
Iteration	49	Cost: 2.322579e-01
Iteration	50	Cost: 2.321067e-01
Iteration	51	Cost: 2.316359e-01
Iteration	52	Cost: 2.311190e-01
Iteration	53	Cost: 2.310144e-01
Iteration	54	Cost: 2.296767e-01
Iteration	55	Cost: 2.293098e-01
Iteration	56	Cost: 2.289738e-01
Iteration	57	Cost: 2.285946e-01
Iteration	58	Cost: 2.284382e-01
Iteration	59	Cost: 2.283791e-01
Iteration	60	Cost: 2.281269e-01
Iteration	61	Cost: 2.280692e-01
Iteration	62	Cost: 2.279445e-01
Iteration	63	Cost: 2.278727e-01
Iteration	64	Cost: 2.276174e-01
Iteration	65	Cost: 2.275821e-01
Iteration	66	Cost: 2.274535e-01
Iteration	67	Cost: 2.274175e-01
Iteration	68	Cost: 2.272772e-01
Iteration	69	Cost: 2.272474e-01
Iteration	70	Cost: 2.271243e-01
Iteration	71	Cost: 2.270930e-01
Iteration	72	Cost: 2.268701e-01
Iteration	73	Cost: 2.266744e-01
Iteration	74	Cost: 2.236910e-01
Iteration	75	Cost: 2.213602e-01
Iteration	76	Cost: 2.185692e-01
Iteration	77	Cost: 2.180727e-01
Iteration	78	Cost: 2.167949e-01
Iteration	79	Cost: 2.156531e-01
Iteration	80	Cost: 2.108199e-01
Iteration	81	Cost: 2.089561e-01
Iteration	82	Cost: 2.041837e-01
Iteration	83	Cost: 2.011422e-01
Iteration	84	Cost: 2.004799e-01
Iteration	85	Cost: 1.988686e-01
Iteration	86	Cost: 1.964732e-01

Iteration	87	Cost: 1.957600e-01
Iteration	88	Cost: 1.898125e-01
Iteration	89	Cost: 1.880149e-01
Iteration	90	Cost: 1.857863e-01
Iteration	91	Cost: 1.847378e-01
Iteration	92	Cost: 1.808871e-01
Iteration	93	Cost: 1.801229e-01
Iteration	94	Cost: 1.793317e-01
Iteration	95	Cost: 1.792268e-01
Iteration	96	Cost: 1.789535e-01
Iteration	97	Cost: 1.787999e-01
Iteration	98	Cost: 1.787706e-01
Iteration	99	Cost: 1.784343e-01
Iteration	100	Cost: 1.783865e-01
Iteration	101	Cost: 1.782204e-01
Iteration	102	Cost: 1.781227e-01
Iteration	103	Cost: 1.781045e-01
Iteration	104	Cost: 1.780330e-01
Iteration	105	Cost: 1.779761e-01
Iteration	106	Cost: 1.779575e-01
Iteration	107	Cost: 1.778883e-01
Iteration	108	Cost: 1.777697e-01
Iteration	109	Cost: 1.763832e-01
Iteration	110	Cost: 1.761266e-01
Iteration	111	Cost: 1.755509e-01
Iteration	112	Cost: 1.752843e-01
Iteration	113	Cost: 1.743353e-01
Iteration	114	Cost: 1.742830e-01
Iteration	115	Cost: 1.741572e-01
Iteration	116	Cost: 1.741282e-01
Iteration	117	Cost: 1.740147e-01
Iteration	118	Cost: 1.740047e-01
Iteration	119	Cost: 1.739648e-01
Iteration	120	Cost: 1.737643e-01
Iteration	121	Cost: 1.736618e-01
Iteration	122	Cost: 1.729417e-01
Iteration	123	Cost: 1.728960e-01
Iteration	124	Cost: 1.725766e-01
Iteration	125	Cost: 1.724088e-01
Iteration	126	Cost: 1.723107e-01
Iteration	127	Cost: 1.721662e-01
Iteration	128	Cost: 1.720531e-01
Iteration	129	Cost: 1.719168e-01
Iteration	130	Cost: 1.717736e-01
Iteration	131	Cost: 1.715603e-01
Iteration	132	Cost: 1.714233e-01
Iteration	133	Cost: 1.713013e-01
Iteration	134	Cost: 1.711228e-01
Iteration	135	Cost: 1.710755e-01
Iteration	136	Cost: 1.708646e-01
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Iteration	183	Cost: 1.392031e-01
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Iteration	189	Cost: 1.388115e-01
Iteration	190	Cost: 1.384382e-01
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Iteration	5	Cost: 2.931455e+00
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Iteration	112	Cost: 1.443470e+00
Iteration	113	Cost: 1.443470e+00
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Iteration	125	Cost: 1.443470e+00
Iteration	126	Cost: 1.443470e+00

Iteration	127	Cost: 1.443470e+00
Iteration	128	Cost: 1.443470e+00
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Iteration	191	Cost: 1.443470e+00

Iteration	192	Cost: 1.443470e+00
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Iteration	197	Cost: 1.443470e+00
Iteration	198	Cost: 1.443470e+00
Iteration	199	Cost: 1.443470e+00
Iteration	200	Cost: 1.443470e+00
Iteration	1	Cost: 8.287440e+01
Iteration	2	Cost: 2.753557e+01
Iteration	3	Cost: 1.416686e+01
Iteration	4	Cost: 5.488365e+00
Iteration	5	Cost: 4.682582e+00
Iteration	6	Cost: 4.062686e+00
Iteration	7	Cost: 4.052924e+00
Iteration	8	Cost: 3.938306e+00
Iteration	9	Cost: 3.847734e+00
Iteration	10	Cost: 3.745160e+00
Iteration	11	Cost: 3.617421e+00
Iteration	12	Cost: 3.509183e+00
Iteration	13	Cost: 3.406213e+00
Iteration	14	Cost: 3.290216e+00
Iteration	15	Cost: 3.182216e+00
Iteration	16	Cost: 3.122297e+00
Iteration	17	Cost: 3.121975e+00
Iteration	18	Cost: 3.111083e+00
Iteration	19	Cost: 3.107625e+00
Iteration	20	Cost: 3.106995e+00
Iteration	21	Cost: 3.105312e+00
Iteration	22	Cost: 3.104947e+00
Iteration	23	Cost: 3.104588e+00
Iteration	24	Cost: 3.103428e+00
Iteration	25	Cost: 3.102685e+00
Iteration	26	Cost: 3.102374e+00
Iteration	27	Cost: 3.101974e+00
Iteration	28	Cost: 3.101616e+00
Iteration	29	Cost: 3.101613e+00
Iteration	30	Cost: 3.101604e+00
Iteration	31	Cost: 3.101604e+00
Iteration	32	Cost: 3.101599e+00
Iteration	33	Cost: 3.101598e+00
Iteration	34	Cost: 3.101597e+00
Iteration	35	Cost: 3.101595e+00
Iteration	36	Cost: 3.101594e+00
Iteration	37	Cost: 3.101592e+00
Iteration	38	Cost: 3.101592e+00
Iteration	39	Cost: 3.101592e+00
Iteration	40	Cost: 3.101592e+00
Iteration	41	Cost: 3.101592e+00
Iteration	42	Cost: 3.101592e+00
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Iteration	69	Cost: 3.101591e+00
Iteration	70	Cost: 3.101591e+00
Iteration	71	Cost: 3.101591e+00
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Iteration	77	Cost: 3.101591e+00
Iteration	78	Cost: 3.101591e+00
Iteration	79	Cost: 3.101591e+00
Iteration	80	Cost: 3.101591e+00
Iteration	81	Cost: 3.101591e+00
Iteration	82	Cost: 3.101591e+00
Iteration	84	Cost: 3.101591e+00
Iteration	86	Cost: 3.101591e+00
Iteration	1	Cost: 8.320954e+01
Iteration	2	Cost: 2.907694e+01
Iteration	3	Cost: 1.613078e+01
Iteration	4	Cost: 7.814702e+00
Iteration	5	Cost: 7.711843e+00
Iteration	6	Cost: 7.588232e+00
Iteration	7	Cost: 7.481019e+00
Iteration	8	Cost: 7.347791e+00
Iteration	9	Cost: 7.337625e+00
Iteration	10	Cost: 7.322456e+00
Iteration	11	Cost: 7.315629e+00
Iteration	12	Cost: 7.294256e+00
Iteration	13	Cost: 7.285757e+00
Iteration	14	Cost: 7.275676e+00
Iteration	15	Cost: 7.275194e+00
Iteration	16	Cost: 7.273592e+00
Iteration	17	Cost: 7.272031e+00
Iteration	18	Cost: 7.269888e+00
Iteration	19	Cost: 7.269128e+00
Iteration	20	Cost: 7.269033e+00
Iteration	21	Cost: 7.268309e+00
Iteration	22	Cost: 7.268211e+00
Iteration	23	Cost: 7.268192e+00
Iteration	24	Cost: 7.268151e+00
Iteration	25	Cost: 7.268150e+00
Iteration	26	Cost: 7.268149e+00
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Iteration	29	Cost: 7.268148e+00
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Iteration	42	Cost: 7.268148e+00
Iteration	43	Cost: 7.268148e+00
Iteration	44	Cost: 7.268148e+00
Iteration	45	Cost: 7.268148e+00
Iteration	46	Cost: 7.268148e+00
Iteration	47	Cost: 7.268148e+00
Iteration	48	Cost: 7.268148e+00
Iteration	49	Cost: 7.268148e+00
Iteration	50	Cost: 7.268148e+00
Iteration	51	Cost: 7.268148e+00
Iteration	52	Cost: 7.268148e+00
Iteration	53	Cost: 7.268148e+00
Iteration	54	Cost: 7.268148e+00
Iteration	1	Cost: 8.416707e+01
Iteration	2	Cost: 3.345965e+01
Iteration	3	Cost: 2.112694e+01
Iteration	4	Cost: 1.621542e+01
Iteration	5	Cost: 1.605198e+01
Iteration	6	Cost: 1.596514e+01
Iteration	7	Cost: 1.596285e+01
Iteration	8	Cost: 1.592089e+01
Iteration	9	Cost: 1.589157e+01
Iteration	10	Cost: 1.589011e+01
Iteration	11	Cost: 1.587849e+01
Iteration	12	Cost: 1.587363e+01
Iteration	13	Cost: 1.586793e+01
Iteration	14	Cost: 1.586791e+01
Iteration	15	Cost: 1.586776e+01
Iteration	16	Cost: 1.586772e+01
Iteration	17	Cost: 1.586769e+01
Iteration	18	Cost: 1.586769e+01
Iteration	19	Cost: 1.586769e+01
Iteration	20	Cost: 1.586769e+01
Iteration	21	Cost: 1.586769e+01
Iteration	22	Cost: 1.586769e+01
Iteration	23	Cost: 1.586769e+01
Iteration	24	Cost: 1.586769e+01
Iteration	25	Cost: 1.586769e+01
Iteration	26	Cost: 1.586769e+01
Iteration	27	Cost: 1.586769e+01
Iteration	28	Cost: 1.586769e+01
Iteration	29	Cost: 1.586769e+01
Iteration	30	Cost: 1.586769e+01
Iteration	31	Cost: 1.586769e+01
Iteration	32	Cost: 1.586769e+01
Iteration	33	Cost: 1.586769e+01
Iteration	35	Cost: 1.586769e+01
Iteration	1	Cost: 8.751844e+01
Iteration	2	Cost: 4.781977e+01
Iteration	3	Cost: 3.633140e+01
Iteration	4	Cost: 3.345113e+01
Iteration	5	Cost: 3.340324e+01
Iteration	6	Cost: 3.337310e+01
Iteration	7	Cost: 3.337236e+01
Iteration	8	Cost: 3.337221e+01
Iteration	9	Cost: 3.337220e+01
Iteration	10	Cost: 3.337220e+01
Iteration	11	Cost: 3.337220e+01
Iteration	12	Cost: 3.337220e+01
Iteration	13	Cost: 3.337220e+01
Iteration	14	Cost: 3.337220e+01

```

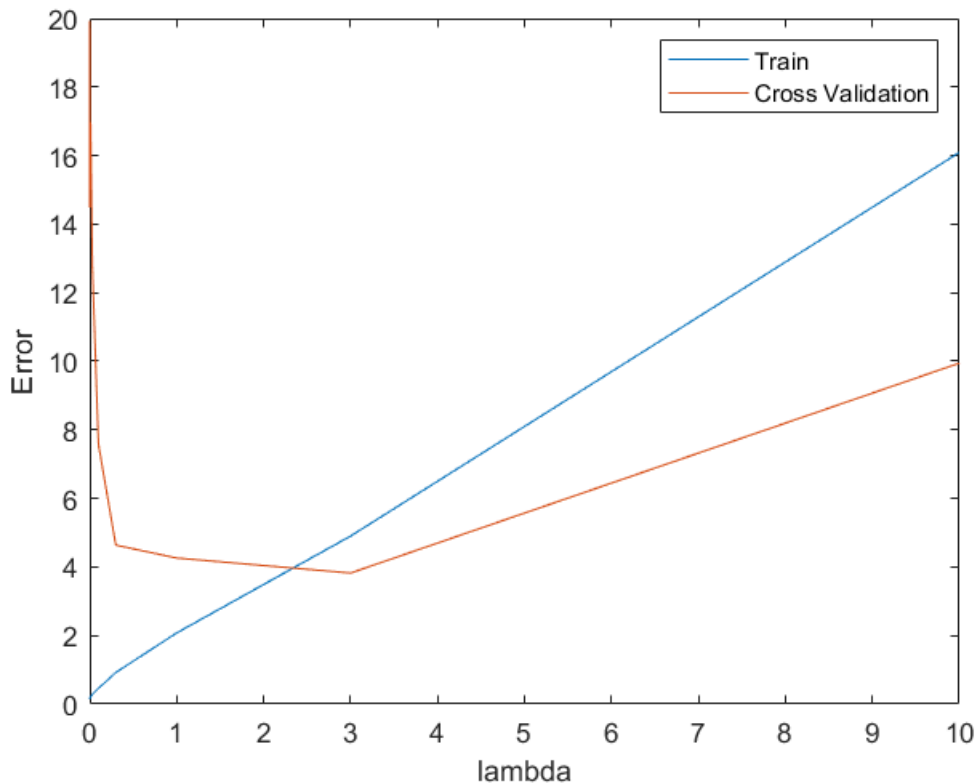
Iteration    15 | Cost: 3.337220e+01
Iteration    16 | Cost: 3.337220e+01
Iteration    17 | Cost: 3.337220e+01
Iteration    18 | Cost: 3.337220e+01
Iteration    19 | Cost: 3.337220e+01
Iteration    20 | Cost: 3.337220e+01
Iteration    21 | Cost: 3.337220e+01
Iteration    22 | Cost: 3.337220e+01

```

```

plot(lambda_vec, error_train, lambda_vec, error_val);
legend('Train', 'Cross Validation');
xlabel('lambda');
ylabel('Error');

```



```

for i = 1:length(lambda_vec)
    if i == 1
        fprintf('lambda\t\tTrain Error\tValidation Error\n');
    end
    fprintf('%f\t%f\t%f\n',lambda_vec(i), error_train(i), error_val(i));
end

```

```

lambda  Train Error Validation Error
0.000000 0.138087 14.486370
0.001000 0.165188 19.929176
0.003000 0.178774 16.813059
0.010000 0.221578 16.986708
0.030000 0.281850 12.828858
0.100000 0.459318 7.587013
0.300000 0.921760 4.636833
1.000000 2.076188 4.260625
3.000000 4.901351 3.822907
10.000000 16.092213 9.945508

```

Лучший коэффициент $\lambda = 3$