Q.N. 1) A hospital administrator wished to study the relationship between patients satisfaction (y) and patient's age (x_1, in years), severity of illness (x_2, an index) and anxiety level (x_3, an index). 46 patients are randomly selected and data is collected. The data is as below

ID	y	x_1	x_2	x_3
1	48	50	51	2.3
2	70	41	44	1.8
3	46	42	50	2.2
4	77	29	50	2.1
5	47	38	55	2.2
6	66	36	49	2.0
7	60	33	49	2.1
8	52	44	58	2.9
9	43	47	53	2.5
10	72	32	46	2.6
11	59	33	42	2.0
12	47	40	48	2.2
13	82	29	48	2.5
14	42	47	50	2.6
15	37	44	51	2.6
16	92	28	46	1.8
17	57	36	46	2.3
18	89	28	43	1.8
19	54	45	48	2.4
20	89	29	48	2.4
21	51	34	51	2.3
22	79	33	56	2.5
23	49	55	51	2.4
24	60	43	50	2.3
25	34	55	54	2.5
26	57	32	52	2.4
27	83	36	49	1.8
28	36	53	57	2.8
29	64	30	51	2.4
30	66	43	53	2.3
31	68	45	51	2.2
32	66	40	48	2.2
33	36	49	54	2.9
34	26	52	62	2.9
35	67	43	53	2.4
36	57	53	54	2.2
37	88	29	46	1.9
38	77	29	52	2.3
39	86	23	41	1.8
40	63	25	49	2.0
41	55	42	51	2.7
42	76	31	47	2.0
43	80	34	49	2.2
44	37	47	60	2.4
45	83	22	51	2.0
46	59	37	53	2.1

a. Fit a multiple linear regression model to the data and state the estimated regression line. How is b_2 interpreted here?

```
> data = scan()
1: 1  48 50 51 2.3
6: 2  70 41 44 1.8
11: 3  46 42 50 2.2
16: 4  77 29 50 2.1
21: 5  47 38 55 2.2
26: 6  66 36 49 2.0
31: 7  60 33 49 2.1
36: 8  52 44 58 2.9
41: 9  43 47 53 2.5
46: 10 72 32 46 2.6
51: 11 59 33 42 2.0
56: 12 47 40 48 2.2
61: 13 82 29 48 2.5
66: 14 42 47 50 2.6
71: 15 37 44 51 2.6
76: 16 92 28 46 1.8
81: 17 57 36 46 2.3
86: 18 89 28 43 1.8
91: 19 54 45 48 2.4
96: 20 89 29 48 2.4
101: 21 51 34 51 2.3
106: 22 79 33 56 2.5
111: 23 49 55 51 2.4
116: 24 60 43 50 2.3
121: 25 34 55 54 2.5
126: 26 57 32 52 2.4
131: 27 83 36 49 1.8
136: 28 36 53 57 2.8
141: 29 64 30 51 2.4
146: 30 66 43 53 2.3
151: 31 68 45 51 2.2
156: 32 66 40 48 2.2
161: 33 36 49 54 2.9
166: 34 26 52 62 2.9
171: 35 67 43 53 2.4
176: 36 57 53 54 2.2
181: 37 88 29 46 1.9
186: 38 77 29 52 2.3
191: 39 86 23 41 1.8
196: 40 63 25 49 2.0
```

```
201: 41 55 42 51 2.7
206: 42 76 31 47 2.0
211: 43 80 34 49 2.2
216: 44 37 47 60 2.4
221: 45 83 22 51 2.0
226: 46 59 37 53 2.1
231:
Read 230 items
> M = matrix(data, ncol=5, byrow=T)
> M
      [,1] [,2] [,3] [,4] [,5]
 [1,]    1   48   50   51  2.3
 [2,]    2   70   41   44  1.8
 [3,]    3   46   42   50  2.2
 [4,]    4   77   29   50  2.1
 [5,]    5   47   38   55  2.2
 [6,]    6   66   36   49  2.0
 [7,]    7   60   33   49  2.1
 [8,]    8   52   44   58  2.9
 [9,]    9   43   47   53  2.5
[10,]   10   72   32   46  2.6
[11,]   11   59   33   42  2.0
[12,]   12   47   40   48  2.2
[13,]   13   82   29   48  2.5
[14,]   14   42   47   50  2.6
[15,]   15   37   44   51  2.6
[16,]   16   92   28   46  1.8
[17,]   17   57   36   46  2.3
[18,]   18   89   28   43  1.8
[19,]   19   54   45   48  2.4
[20,]   20   89   29   48  2.4
[21,]   21   51   34   51  2.3
[22,]   22   79   33   56  2.5
[23,]   23   49   55   51  2.4
[24,]   24   60   43   50  2.3
[25,]   25   34   55   54  2.5
[26,]   26   57   32   52  2.4
[27,]   27   83   36   49  1.8
[28,]   28   36   53   57  2.8
[29,]   29   64   30   51  2.4
[30,]   30   66   43   53  2.3
[31,]   31   68   45   51  2.2
[32,]   32   66   40   48  2.2
[33,]   33   36   49   54  2.9
```

```
[34,]  34  26  52  62  2.9
[35,]  35  67  43  53  2.4
[36,]  36  57  53  54  2.2
[37,]  37  88  29  46  1.9
[38,]  38  77  29  52  2.3
[39,]  39  86  23  41  1.8
[40,]  40  63  25  49  2.0
[41,]  41  55  42  51  2.7
[42,]  42  76  31  47  2.0
[43,]  43  80  34  49  2.2
[44,]  44  37  47  60  2.4
[45,]  45  83  22  51  2.0
[46,]  46  59  37  53  2.1
> y = M[,2]
> x1 = M[,3]
> x2 = M[,3]
> x1 = M[,3]
> x2 = M[,4]
> x3 = M[,5]
> y
 [1] 48 70 46 77 47 66 60 52 43 72 59 47 82 42 37 92 57 89 54 89 51 79 49 60 34 57 83 36 64 66
68 66 36 26 67 57 88 77 86 63 55 76 80 37 83 59
> x1
 [1] 50 41 42 29 38 36 33 44 47 32 33 40 29 47 44 28 36 28 45 29 34 33 55 43 55 32 36 53 30 43
45 40 49 52 43 53 29 29 23 25 42 31 34 47 22 37
> x2
 [1] 51 44 50 50 55 49 49 58 53 46 42 48 48 50 51 46 46 43 48 48 51 56 51 50 54 52 49 57 51 53
51 48 54 62 53 54 46 52 41 49 51 47 49 60 51 53
> x3
 [1] 2.3 1.8 2.2 2.1 2.2 2.0 2.1 2.9 2.5 2.6 2.0 2.2 2.5 2.6 2.6 1.8 2.3 1.8 2.4 2.4 2.3 2.5 2.4 2.3 2.5
2.4 1.8 2.8 2.4 2.3 2.2 2.2 2.9 2.9 2.4 2.2 1.9 2.3 1.8 2.0 2.7 2.0 2.2 2.4 2.0 2.1
> model = lm(y~x1+x2+x3)
> model

Call:
lm(formula = y ~ x1 + x2 + x3)

Coefficients:
(Intercept)           x1           x2           x3
    158.491       -1.142       -0.442      -13.470
```

Y = 158.491-1.142 x1 -0.442x2 -13.470 x3

b: interpretation –

If x2 is incremented by 1 unit, then Y is decreased by 0.442

b. Calculate the coefficient of multiple determination. What does it indicate?

```
> summary(model)

Call:
lm(formula = y ~ x1 + x2 + x3)

Residuals:
    Min      1Q  Median      3Q     Max 
-18.3524 -6.4230  0.5196  8.3715 17.1601 

Coefficients:
            Estimate Std. Error t value Pr(>t)
(Intercept) 158.4913    18.1259   8.744 5.26e-11 ***
x1           -1.1416     0.2148  -5.315 3.81e-06 ***
x2           -0.4420     0.4920  -0.898  0.3741
x3          -13.4702     7.0997  -1.897  0.0647 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 10.06 on 42 degrees of freedom
Multiple R-squared:  0.6822,	Adjusted R-squared:  0.6595 
F-statistic: 30.05 on 3 and 42 DF,  p-value: 1.542e-10
```

coefficient of multiple determination indicate that 68% of variation in Y can be explained using this model.

c. Consider the cases 2, 17 and 45. Obtain the DFFITS, DFBETAS and Cook's distance values for these cases to assess their influence.

```
> dffits(model)
         1           2           3           4           5           6           7           8           9          10          11 
12          13          14          15          16          17          18 
 0.003365392  0.091451232 -0.246996349  0.050320039 -0.472136428 -0.062609433 -
0.205259294  0.358895854 -0.101509995  0.281996576 -0.644412890 -0.303009053
0.456008030 -0.181938302 -0.362555091  0.314681047 -0.250205733  0.194527199
        19          20          21          22          23          24          25          26          27          28 
29          30          31          32          33          34          35          36 
 0.012409704  0.568819997 -0.288892901  0.665736971  0.333767209  0.067884177 -
0.146459074 -0.248559272  0.428074486  0.032517582 -0.151415503  0.222316502
0.311603405  0.079305897 -0.146607260 -0.346472767  0.243140986  0.554322557
```

```
        37          38          39          40          41          42          43          44          45          46
 0.225642970  0.166353621 -0.162220199 -0.608739745  0.109220429  0.013388989
0.196815026 -0.463926743 -0.040681364 -0.158696762
> cooks.distance(model)
         1           2           3           4           5           6           7           8           9          10          11
12          13          14          15          16          17          18
2.900516e-06 2.139423e-03 1.499893e-02 6.478162e-04 5.412369e-02 1.001951e-03 1.047914e-
02 3.234629e-02 2.624352e-03 2.019402e-02 9.880424e-02 2.222432e-02 5.136521e-02
8.405912e-03 3.208037e-02 2.470201e-02 1.569901e-02 9.608143e-03
        19          20          21          22          23          24          25          26          27          28
29          30          31          32          33          34          35          36
3.943740e-05 7.656783e-02 2.017892e-02 1.051334e-01 2.801513e-02 1.176276e-03 5.468430e-
03 1.545368e-02 4.528550e-02 2.707350e-04 5.828548e-03 1.228245e-02 2.381480e-02
1.604332e-03 5.484993e-03 3.034942e-02 1.448430e-02 7.530661e-02
        37          38          39          40          41          42          43          44          45          46
1.280037e-02 7.030790e-03 6.711882e-03 8.666240e-02 3.046051e-03 4.590508e-05 9.596369e-
03 5.384016e-02 4.237406e-04 6.399528e-03
> dfbetas(model)
    (Intercept)           x1            x2            x3
1   0.0005977634  0.002847889 -0.0006341128 -0.0009826358
2   0.0667690225  0.060203851 -0.0362653798 -0.0465534843
3  -0.0667217871 -0.136382137  0.0176729289  0.0988338741
4  -0.0026372492 -0.032028397  0.0224854005 -0.0123360922
5   0.2494351219  0.090297896 -0.4042663198  0.2723082583
6  -0.0186375583 -0.009511463 -0.0142162462  0.0434781067
7  -0.0510672522  0.059338023 -0.0365873813  0.0676832949
8  -0.2592765845 -0.123105467  0.1081909209  0.1996987750
9   0.0236600857 -0.048291137  0.0037717284 -0.0142146419
10  0.0881603497 -0.090669763 -0.1887171669  0.2448269718
11 -0.5896728730 -0.138109410  0.5151339305 -0.0841365297
12 -0.1812409112 -0.140916164  0.1541563256  0.0171591850
13  0.0626470945 -0.276024733 -0.1768922049  0.3582111028
14 -0.0375319947 -0.075293893  0.1176897412 -0.1080204284
15 -0.0113975594 -0.063121441  0.1793991863 -0.2491336705
16  0.1574109167 -0.053963638  0.0295509954 -0.1787824571
17 -0.1608689658 -0.011828324  0.1990879145 -0.1316542898
18  0.1609428294 -0.002936561 -0.0748397156 -0.0553887483
19  0.0060366064  0.006911791 -0.0091868548  0.0043987924
20  0.0991076408 -0.363089223 -0.1899886913  0.3899851559
21  0.0510228536  0.166479948 -0.0816495185 -0.0380787610
22 -0.4491347867 -0.471110889  0.4432301688  0.0892699630
23  0.0664797118  0.298927532 -0.1129064128 -0.0409802738
24  0.0192973485  0.038208905 -0.0209676397 -0.0038652448
25  0.0206776231 -0.116399385  0.0049904961  0.0222610195
```

26	0.0854958784	0.188118427	-0.0787650863	-0.0843506436
27	0.0932095312	0.099089883	0.1573546358	-0.3774349831
28	-0.0182159601	0.010336746	0.0040734580	0.0102249019
29	0.0321428164	0.120999575	-0.0235788056	-0.0689797305
30	-0.0702029968	0.065377757	0.1035080891	-0.0976471158
31	0.0384199516	0.209484367	0.0222142015	-0.1646345482
32	0.0474357874	0.036881679	-0.0403469980	-0.0044910360
33	0.0371805846	-0.016165836	0.0477061728	-0.1117051360
34	0.3044116516	0.012703850	-0.2058902900	-0.0425205531
35	-0.0903192879	0.049090338	0.0754470213	-0.0207646816
36	-0.0650060912	0.407346242	0.1623574060	-0.3626774537
37	0.1315259209	-0.045090781	-0.0141269568	-0.0901781053
38	-0.0569816037	-0.135331586	0.0793796784	0.0190773191
39	-0.1352258938	0.035944346	0.0814164840	0.0023581334
40	-0.0172343213	0.417182739	-0.2498613962	0.1613648361
41	-0.0022583374	-0.007841629	-0.0529451445	0.0923158561
42	0.0072189261	-0.002773363	-0.0010070184	-0.0042619237
43	0.0559647256	-0.063679532	-0.0120363946	0.0043200454
44	0.3366251696	-0.017964869	-0.4044535727	0.2367140455
45	0.0085456656	0.030682507	-0.0247159625	0.0112499915
46	0.0499214671	0.015998781	-0.1190937782	0.1102081200

```
> influence.measures(model)
Influence measures of
	 lm(formula = y ~ x1 + x2 + x3) :
```

	dfb.1_	dfb.x1	dfb.x2	dfb.x3	dffit	cov.r	cook.d	hat	inf
1	0.000598	0.00285	-0.000634	-0.000983	0.00337	1.195	2.90e-06	0.0782	
2	0.066769	0.06020	-0.036265	-0.046553	0.09145	1.295	2.14e-03	0.1536	*
3	-0.066722	-0.13638	0.017673	0.098834	-0.24700	0.969	1.50e-02	0.0345	
4	-0.002637	-0.03203	0.022485	-0.012336	0.05032	1.164	6.48e-04	0.0580	
5	0.249435	0.09030	-0.404266	0.272308	-0.47214	0.978	5.41e-02	0.0903	
6	-0.018638	-0.00951	-0.014216	0.043478	-0.06261	1.147	1.00e-03	0.0471	
7	-0.051067	0.05934	-0.036587	0.067683	-0.20526	1.014	1.05e-02	0.0335	
8	-0.259277	-0.12311	0.108191	0.199699	0.35890	1.180	3.23e-02	0.1369	
9	0.023660	-0.04829	0.003772	-0.014215	-0.10151	1.126	2.62e-03	0.0434	
10	0.088160	-0.09067	-0.188717	0.244827	0.28200	1.308	2.02e-02	0.1860	*
11	-0.589673	-0.13811	0.515134	-0.084137	-0.64441	0.929	9.88e-02	0.1171	
12	-0.181241	-0.14092	0.154156	0.017159	-0.30301	0.913	2.22e-02	0.0372	
13	0.062647	-0.27602	-0.176892	0.358211	0.45601	1.085	5.14e-02	0.1212	
14	-0.037532	-0.07529	0.117690	-0.108020	-0.18194	1.166	8.41e-03	0.0869	
15	-0.011398	-0.06312	0.179399	-0.249134	-0.36256	0.967	3.21e-02	0.0610	
16	0.157411	-0.05396	0.029551	-0.178782	0.31468	1.081	2.47e-02	0.0832	

```
17 -0.160869 -0.01183  0.199088 -0.131654 -0.25021 1.085 1.57e-02 0.0671
18  0.160943 -0.00294 -0.074840 -0.055389  0.19453 1.178 9.61e-03 0.0967
19  0.006037  0.00691 -0.009187  0.004399  0.01241 1.191 3.94e-05 0.0752
20  0.099108 -0.36309 -0.189989  0.389985  0.56882 0.880 7.66e-02 0.0876
21  0.051023  0.16648 -0.081650 -0.038079 -0.28889 0.905 2.02e-02 0.0332
22 -0.449135 -0.47111  0.443230  0.089270  0.66574 0.921 1.05e-01 0.1195
23  0.066480  0.29893 -0.112906 -0.040980  0.33377 1.175 2.80e-02 0.1289
24  0.019297  0.03821 -0.020968 -0.003865  0.06788 1.124 1.18e-03 0.0329
25  0.020678 -0.11640  0.004990  0.022261 -0.14646 1.205 5.47e-03 0.1029
26  0.085496  0.18812 -0.078765 -0.084351 -0.24856 1.065 1.55e-02 0.0594
27  0.093210  0.09909  0.157355 -0.377435  0.42807 1.072 4.53e-02 0.1096
28 -0.018216  0.01034  0.004073  0.010225  0.03252 1.227 2.71e-04 0.1030
29  0.032143  0.12100 -0.023579 -0.068980 -0.15142 1.151 5.83e-03 0.0706
30 -0.070203  0.06538  0.103508 -0.097647  0.22232 1.015 1.23e-02 0.0380
31  0.038420  0.20948  0.022214 -0.164635  0.31160 0.976 2.38e-02 0.0509
32  0.047436  0.03688 -0.040347 -0.004491  0.07931 1.126 1.60e-03 0.0372
33  0.037181 -0.01617  0.047706 -0.111705 -0.14661 1.246 5.48e-03 0.1286
34  0.304412  0.01270 -0.205890 -0.042521 -0.34647 1.282 3.03e-02 0.1843
35 -0.090319  0.04909  0.075447 -0.020765  0.24314 0.952 1.45e-02 0.0309
36 -0.065006  0.40735  0.162357 -0.362677  0.55432 1.078 7.53e-02 0.1429
37  0.131526 -0.04509 -0.014127 -0.090178  0.22564 1.091 1.28e-02 0.0624
38 -0.056982 -0.13533  0.079380  0.019077  0.16635 1.156 7.03e-03 0.0777
39 -0.135226  0.03594  0.081416  0.002358 -0.16222 1.254 6.71e-03 0.1358
40 -0.017234  0.41718 -0.249861  0.161365 -0.60874 0.839 8.67e-02 0.0868
41 -0.002258 -0.00784 -0.052945  0.092316  0.10922 1.196 3.05e-03 0.0900
42  0.007219 -0.00277 -0.001007 -0.004262  0.01339 1.153 4.59e-05 0.0450
43  0.055965 -0.06368 -0.012036  0.004320  0.19682 0.991 9.60e-03 0.0272
44  0.336625 -0.01796 -0.404454  0.236714 -0.46393 1.224 5.38e-02 0.1810
45  0.008546  0.03068 -0.024716  0.011250 -0.04068 1.300 4.24e-04 0.1539   *
46  0.049921  0.01600 -0.119094  0.110208 -0.15870 1.151 6.40e-03 0.0726
```

If |DFBETAS| > 2/sqrt(46) i.e 0.3 then its influential

```
> influence.measures(model)$infmat[c(2,17,45),]
        dfb.1_      dfb.x1      dfb.x2      dfb.x3       dffit    cov.r       cook.d        hat
2   0.066769023  0.06020385 -0.03626538 -0.04655348  0.09145123 1.295210 0.0021394233
0.15361084
17 -0.160868966 -0.01182832  0.19908791 -0.13165429 -0.25020573 1.085178 0.0156990120
0.06706793
45  0.008545666  0.03068251 -0.02471596  0.01124999 -0.04068136 1.300270 0.0004237406
0.15385909
```