1. (a) Let the number of full-time consultants working in the morning, afternoon, and evening shifts be X1, X2 and X3 respectively.

Following are the other required assumptions.

Number of part time consultants working from 8am to noon= y1

Number of part time consultants working from noon to 4pm= y2

Number of part time consultants working from 4pm to 8pm= y3

Number of part time consultants working from 8pm to midnight= y4

As per the given problem,

Minimum number of employees working from 8am to noon=4

i.e., x1+y1>=4

Similarly considering other conditions

X1+x2+y2>=8

X2+x3+y3>=10

X3+y4>=6

X1>=y1 for 8am to noon shift

X1+x2>=y2 for noon to 4pm shift

X2+x3>=y3 for 4pm to 8pm shift

X3>=y4 for 8pm to midnight shift

Amount earned by a full-time consultant in a day= 14\*8= $112

Amount earned by a part time consultant in a day= 12\*4= $48

Cost to be minimized= 112\*(x1+x2+x3) + 48\*(y1+y2+y3+y4)

Considering that at least one full-time consultant is required for every part time consultant in every of the 4 shifts, the minimum number of full-time employees required is 28/4= 7

Considering all the above conditions:

X1+y1+x1+x2+y2+x2+x3+y3+x3+y4>=28

2(x1+x2+x3) + (y1+y2+y3+y4)>=28

2\*7 + (y1+y2+y3+y4)>=28

So, the number of part time employees required should be >=14

Minimum cost= 112\*7 + 48\*14= 784 + 672= $1456

(b) There is a one hour break in the 8 hour shift for full time consultants and no break for part time consultants.

Lunch time for Full- time consultants start 3rdhr or 4th hr.

Let’s consider the minimum cost function is Zmin1.

Therefore,

Zmin1 = 8\*14(F1 + F2 + F3) -14\*(F1 + F2 + F3) + 4\*12(P1 + P2 + P3 + P4).

The minimum constraints will remain same, so

= 112(2+2+3) – 14(2+2+3) +4\*12(2+4+5+3)

= 1358

Zmin – Zmin1 = 1456 – 1358

= 98

2. Let the number of collegiate backpacks produced= x  
Let the number of mini backpacks produced= y  
Total profit z= 32x + 24y  
Total nylon fabric required= 3x + 2y  
Therefore, according to the given condition, 3x + 2y<= 5000  
Also, x<=1000 and y<=1200  
Total labor required= 45x + 40y  
Available labor= 35\*40\*60= 84000 minutes  
So 45x + 40y <=84000  
Formulating the LP  
Maximize Z= 32x + 24y  
Subject to, 3x + 2y<=5000  
 X<=1000  
 Y<=1200  
 45x + 40y<=84000  
 X, y>=0

Solution is in the attached excel file

3.

a) Let the number of large products made by plant 1 be x1

Let the number of large products made by plant 2 be x2

Let the number of large products made by plant 3 be x3

Let the number of medium products made by plant 1 be y1

Let the number of medium products made by plant 2 be y2

Let the number of medium products made by plant 3 be y3

Let the number of small products made by plant 1 be z1

Let the number of small products made by plant 2 be z2

Let the number of small products made by plant 3 be z3

The decision variables can be defined as follows:

X1+y1+z1<=750

X2+y2+z2<=900

X3+y3+z3<=450

20x1+15y1+12z1<=13000

20x2+15y2+12z2<=12000

20x3+15y3+12z3<=5000

X1+x2+x3<=900

Y1+y2+y3<=1200

Z1+z2+z3<=7500

Where x1, x2, x3, y1, y2, y3, z1, z2, z3>=0