SHORT ANSWERS FOR PRACTICE PROBLEMS (MIDTERM 2)

1(a)

Deseasonalized data

	2005	2006
1st half	50.00	58.15
2nd half	54.44	62.22
Avg	52.22	60.20

Deseasonalized then detrended data

	2004	2005
1st half	50.00	50.18
2nd half	50.44	50.22

$G = (60.20-52.22)/2 \approx 4$

$S_0 = 62.22$

$F_{1,2007} = (62.22 + 4)(1.1) = 72.84$

$F_{2,2007} = [62.22 + 2(4)](0.9) = 63.2$

(a')

Original data

	2005	2006
1st half	55.00	64.00
2nd half	49.00	56.00
Avg	52.00	60.00

$G = (60-52)/2=4$

Calculating S values

	2005	2006
1st half	52-0.5(4) = 50	60-0.5(4) = 58
2nd half	52+0.5(4)= 54	60+0.5(4) =62

Calculating seasonal factors

		Average	Normalized
c1 = 55/50 = 1.10	c3 = 64/58 = 1.10	1.10	1.09
c2 = 49/54 = 0.91	c4= 56/62 = 0.90	0.91	0.91

Remainder of initialization similar to part (a)

(b) Baseball season is from April through October, but some baseball socks are purchased before the beginning of the season (but not **too** early). So I would use two-month periods starting in March (e.g., Mar/Apr, May/June, July-Aug, Sept/Oct, Nov/Dec, Jan/Feb). Sales in the last two periods would be almost zero. By September, most of the potential buyers would buy new socks only if they are desperate. So the seasonal factors for these seasons would probably be about 2.5, 2, 1, 0.5, 0, 0. The seasonality of demand could be affected by the weather, which is unpredictable, so we might want to limit γ to 0.25 or 0.3. The baseline and trend could be affected by other random effects such as the economy or whether certain teams in large metropolitan areas are doing well, so α of about 0.15 and β of about 0.1 would be appropriate.

2 (a). When forecasting for 2007, the weight on data in 2004 is $\alpha (1-\alpha)^2 = 0.128$. If we assume that the actual day was at the mid-point of May (May 16th), then we can be off by at most 15 days. So the error in the forecast is at most 15(0.128)=1.92. Unless two days matters, it's probably not worth making a phone call.

(b)
Notes: May 31 is the 152nd day of the year (2004 is a leap year)
The company had been using a tracking signal since 1998 and MAD was 5.0 at the end of 2001. Therefore the sum of the absolute values of the errors from 1998 through 2001 was 4(5) = 20.

Year	Forecast (at end of year)	Smoothed Error	MAD	SE/MAD
2002	0.2(98)+0.8(98)=98	.2(98-98) +.8(4)=3.2	[0+20]/5=4.0	3.2/4.00=0.80
2003	0.2(99)+0.8(98)=98.2	.2(98.2-99) +.8(3.2)=2.72	[0.2+0+20]/6 =3.37	2.72/3.37=0.81
2004	0.2(152)+0.8(98.2)=108.96	.2(98.2-152) +.8(2.72)= -8.58	[53.8+20.2]/7 =10.57	8.58/10.57=0.81

For k = 2, threshold is $\frac{2(1.25)\sqrt{0.2}}{2-0.2} = .62$, so forecast was already out of control in 2002.

3.

		Period						
		1	2	3	4	5	6	7
Gross Requirements		80	100	0	110	50	20	90
Scheduled Receipts		0	100	0	70	110	0	90
On Hand Inventory	80	0	0	0	-40*	20	0	0
Planned Orders		70	110	0	90			

*somebody forgot to order enough

4. See below for supporting calculations.

	Week 1	2	3	4	5	6
Finished Product						
Gross Requirements	100	80	100	120	80	100
Scheduled Receipts	0	180	0	200	0	100
On-Hand Inventory 100	0	100	0	80	0	0
Planned orders	180	0	200	0	100	--
Assembly #1						
Gross Requirements	180	0	200	0	100	--
Scheduled Receipts		100	80	0	100	--
On-Hand Inventory 200	20	120	0	0	0	--
Planned Orders	80	0	100	0	--	--

For finished product, use WW algorithm for net demands (depleting initial on-hand inventory)= (0, 80, 100, 120, 80, 100). Start the calculations in period 2.

	2	3	4	5	6
2	1000	1500	2700		
3		2000	2600		
4			2500	2900	3900
5				3500	4000
6					3900

Two solutions: $X_2 = 180$, $X_4=300$ OR $X_2=180$, $X_4=200$, $X_6=100$. The latter is better if, for example, you expect engineering changes.

Assembly #1: Net requirements=(0, 0, 80, 0, 100, 0)
Use Silver-Meal starting in period 3
$C(1)/1 = 50/1 = 50$
$C(2)/2 = [50 + 0]/2 = 25$
$C(3)/3 =[50 + 0 + 2(1)(100)]/3 = 83.33$
$X_3=80$, $X_5 = 100$

5. labor cost per unit = 2.50
   total unit cost = 7.50 + 2.50 = 10.00
   overtime premium per unit = .5(2.50) = 1.25 up to 12 hours/day
   2.50 above 12 hours/day
   hiring cost = 40(10) = 400
   firing cost = 2(40)(10) = 800

   inventory holding cost /unit/quarter = .40(10)/4 = 1.00

   Each employee can produce 4(160)(3) = 1920 units per quarter (let's say 2000 to make it easy—if we use 13 weeks per quarter, then the number is 2080, but there are some holidays)

   Equivalent employees needed each quarter (using demands of 200K, 100K, 400K and 150K):

   Q1: 100
   Q2: 50
   Q3: 200
   Q4: 75

   Hiring + firing cost = 1200; if this is amortized over 2000 units in one quarter, cost per unit is only $0.60. This is cheaper than carrying inventory or producing on overtime. The only problem is that in Q3, total demand is more than the amount that can be produced on 3 shifts. Overtime is more expensive than carrying inventory, so we should move 20 employees' worth of work to the second quarter. The resulting workforce levels would then be:

   Q1 = 100 (divided between 2 shifts in any manner that is practical)
   Q2 = 70 (divided between 2 shifts)
   Q3 = 180 (3 full shifts)
   Q4 = 75 (divided between 2 shifts)

(b) Formulation with reduced demand:

W_{it} = employees on shift i in period t
H_{it} = employees hired on shift i in period t
F_{it}= employees fired on shift i in period t
X_{it} = regular time production on shift i in period t(units)
Y_{it} = overtime production on shift i in period t(at 150%)
Z_{it} = overtime production on shift i in period t (at 200%)
I_t = inventory at end of period t

All of the raw material costs are sunk (not controllable) so I will exclude them from the formulation (except for their effect on the holding costs).

$$\text{Min } 1600 \sum_i \sum_t W_{it} + 15 \sum_i \sum_t Y_{it} + 20 \sum_i \sum_t Z_{it} + 400 \sum_i \sum_t H_{it} + 800 \sum_i \sum_t F_{it} + 1 \sum_t I_t$$

s.t. $W_{it} = W_{i,t-1} + H_{it} - F_{i,t-1}$ for all i and t

$I_t = I_{t-1} + \Sigma_i (X_{it} + Y_{it} + Z_{it}) - D_t$ for all t

$X_{it} \le 2000\, W_{it}$ for all i and t

$Y_{it} \le 1000\, W_{it}$ for all i and t

Constraint on Z_{it} is not stated but a limit needs to be imposed for practical reasons

$W_{it} \le 60$ for all i and t

Non-negativity constraints on all decision variables

(c) Regarding kanbans: The uniform company probably makes many different styles, sizes and colors, and total demand fluctuates wildly and changing the workforce level is relatively inexpensive, so the production plan will be closer to a "chase" strategy than to a "level" strategy. Furthermore, the demand for each specific product probably fluctuates over time. Because both total volume and mix are changing, it may be difficult to use a kanban system. The system will not be able to respond to changes in demand.

6.
C(1)/1 = 1000/1 = 1000
C(2)/2 = [1000 + 200(2)]/2 = 700
C(3)/3 = [1000+ 200(2) + 100(2)(2)]/3 = 600
C(4)/4 = [1000+ 200(2) + 100(2)(2) + 250(2)(3)]/4= 825 stop after 3 periods

So X_1 = 500 + 200 + 100 =800
Start over from period 4
C(1)/1 = 1000
C(2)/2 = [1000+400(2)]/2 = 900
C(3)/3 = [1000+400(2) + 200(2)(2)]/3= 866.66

Tentatively X_4 = 250+400+200 = 850, but more could be added to the batch after demand in June and later periods becomes known.

Wagner-Whitin Table

	1	2	3	4	5	6
1	1000	1400	1800	3300		
2		2000	2200	3200		
3			2400	2900		
4				2800	3600	4400
5					3800	4200
6						4600

Optimal solution is X_1 = 800, X_4 = 250, X_5=600. Total cost is 4200. Silver-Meal solution has a cost of 4400.