Candidate Name:__________________

Student ID:__________________

Signature:__________________

THE UNIVERSITY OF NEW SOUTH WALES

SCHOOL OF ECONOMICS

Business Forecasting

ECON2209/5248

Final Examination, Session 1, 2006

1. Total time allowed: 2 hours 30 minutes.
2. Total number of questions: 4
3. Total marks for this exam: 60
4. Attempt all questions. The value for each part of the questions is given.
5. Calculators may be used.
6. Answers must be written in black or blue ink. Pencils may only be used for drawing, sketching or graphical work.
7. All answers must be written on the exam answer-booklet. Do NOT write any answers on this exam paper.
8. Some notation, useful formulae and statistical tables are given in the Appendix at the end of this paper.
9. This paper may NOT be retained by candidate.

Question 1

(a) State the classical decomposition (additive and standardized) for a time series, say $\{y_t\}$. Characterize each component briefly. [4 marks]

(b) Outline a procedure that seasonally adjusts a time series, say $\{y_t\}$. [5 marks]

(c) The following table contains the quarterly retail sales of a software company from 1998q1 to 1999q4. The MA(4)-smoothed series is also included.

Retail Sales 1998q1–1999q4

	98q1	98q2	98q3	98q4	99q1	99q2	99q3	99q4
Actual	25.9	18.0	11.0	26.3	21.2	13.3	13.2	26.6
MA(4)			20.3	19.1	18.0	18.5	18.6	

Here MA(4) is defined as $(y_{t-2} + y_{t-1} + y_t + y_{t+1})/4$. Use the MA(2*4) smoother to estimate the trend series. Report the trend series and the de-trended series with corresponding timing (ie, with an appropriate year and quarter). [3 marks]

(d) The following table contains the monthly Yen/$AU exchange rate series from Apr/1999 to Aug/1999.

Exchange Rate Apr/1999–Aug/1999

Apr	May	Jun	Jul	Aug
78.6	78.9	79.7	75.1	70.7

Use the exponential smoother with $\alpha = .8$ to smooth the above series up to Jul/1999 (inclusive). Based on the smoothed series, make a point forecast for the exchange rate at Aug/1999. Comment on the adequacy of the exponential smoother for long-horizon forecasts. [3 marks]

Question 2

(a) By saying that a time series is covariance stationary, what exactly do we mean? [3 marks]

(b) Jan has collected a monthly time series consisting of 167 observations on the differenced log Yen/$AU exchange rate and plotted the sample ACF for the series (see below). Use the $Q_{LB}(2)$ statistic to test whether or not the series is a white-noise process at the 5% level of significance. Write down your hypotheses, decision rule and conclusion. [3 marks]

```
Lag     -1.00      -0.60      -0.20      0.20       0.60       1.00       ACF
        |-+---------+---------+----0----+---------+---------+-|
1       |                          R                          |  0.001073
2       |                          |  R                       |  0.121080
3       |                        R |                          | -0.084039
4       |                         R|                          | -0.052353
5       |                         R|                          | -0.054732
6       |                        R |                          | -0.095489
7       |                          |R                         |  0.044049
8       |                         R|                          | -0.057184
9       |                          | R                        |  0.062974
10      |                          R                          |  0.009568
        |-+---------+---------+----0----+---------+---------+-|

        Here 'R' represents the magnitudes of ACF values.
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(c) Suppose that we have a time series $\{y_t\}_{t=1}^{100}$. How would you compute the sample partial autocorrelation function $\hat{p}(\tau)$ for $\tau = 1, 2, 3$? [3 marks]

(d) Consider the AR(1) process $\{y_t\}$, where $y_t = \phi y_{t-1} + c + \varepsilon_t$ with $|\phi| < 1$ and c being constant parameters. Here $\varepsilon_t \sim$ iid $\text{WN}(0, \sigma^2)$.

(i) Find the mean μ and the autocovariance $\gamma(\tau)$ of the above process. [3 marks]

(ii) Suppose that you know the values of $\Omega_T = \{y_1, \ldots, y_T\}$, ϕ and c. Find the optimal point forecast (2-step ahead) under the MSFE. [3 marks]

Question 3

(a) Inspect the ACF and PACF plots of the observed time series $\{y_t\}$ below.

```
Lag     -1.00     -0.60     -0.20     0.20      0.60      1.00     ACF
        |-+---------+---------+----0----+---------+---------+-|
1       |                       +  |  +             R         | 0.69096
2       |                     +    |    +     R               | 0.43271
3       |                     +    |    +  R                  | 0.30402
4       |                     +    |    R                     | 0.19814
5       |                    +     |  R  +                    | 0.13667
6       |                    +     | R   +                    | 0.06957
7       |                    +     |R    +                    | 0.04214
8       |                    +     | R   +                    | 0.09846
9       |                    +     |  R  +                    | 0.11726
10      |                    +     |  R  +                    | 0.13686
        |-+---------+---------+----0----+---------+---------+-|


Lag     -1.00     -0.60     -0.20     0.20      0.60      1.00   PACF
        |-+---------+---------+----0----+---------+---------+-|
1       |                       +  |  +             R         |  0.69096
2       |                       +R |  +                       | -0.08558
3       |                       +  | R+                       |  0.07437
4       |                       + R|  +                       | -0.04275
5       |                       +  |R +                       |  0.02784
6       |                       + R|  +                       | -0.05811
7       |                       +  |R +                       |  0.03507
8       |                       +  |  R                       |  0.12675
9       |                       +  R  +                       | -0.00659
10      |                       +  | R+                       |  0.06543
        |-+---------+---------+----0----+---------+---------+-|

        Here 'R' represents the magnitudes of ACF and PACF values
        and '+' represents the two-standard-deviation bands.
```

Based on the above information, choose an ARMA(p,q) model for the series $\{y_t\}$, ie, specify the values of p and q. Explain your choice briefly. [5 marks]

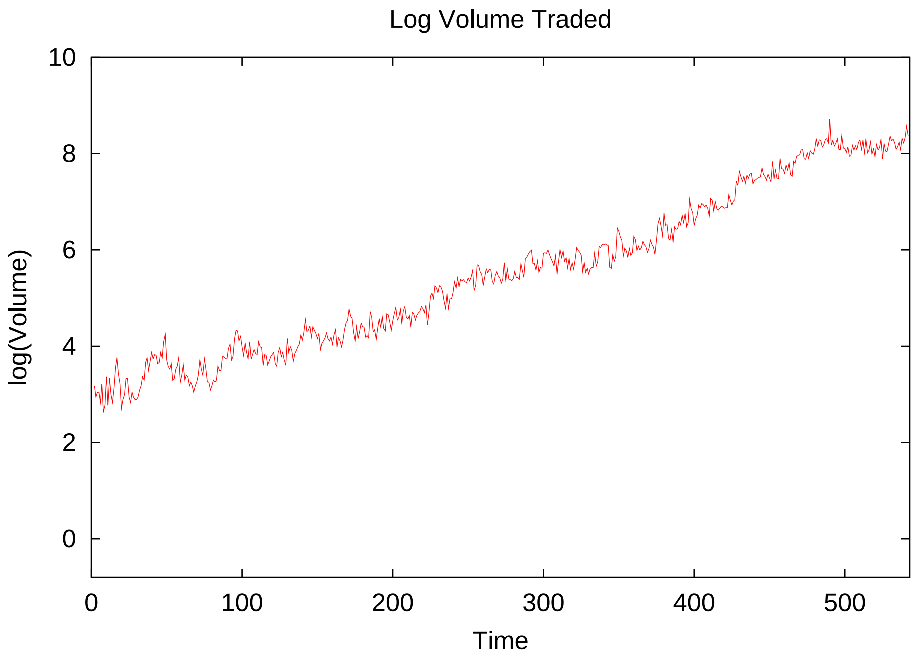
(b) Finding the correct p and q for an ARMA(p,q) model based solely on the sample ACF and PACF may be difficult. Recommend an alternative approach to determine the values of p and q. List the steps of your recommendation. [5 marks]

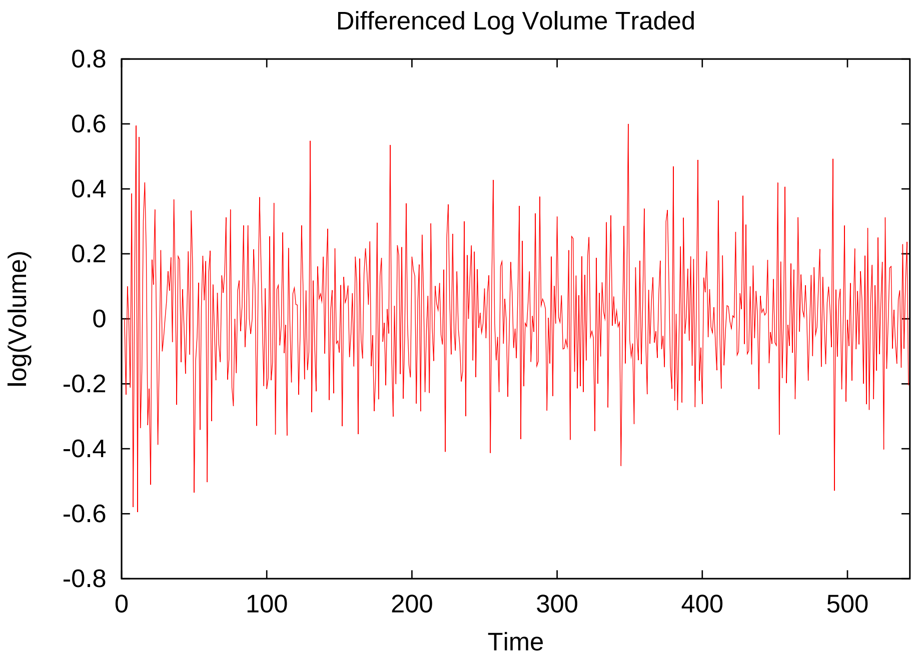
(c) When choosing a stationary ARMA model, we require that the model be a "well-defined" one. What do we mean by a "well-defined" ARMA model? [2 marks]

(d) Suppose that a stationary time series with 50 observations can be fitted by an MA(1) model. How would you estimate the MA(1) model using the technique of least squares? [3 marks]

Question 4

An investment consultant firm believes that its operation profit is strongly influenced by the volume of shares traded on the New York Stock Exchange (NYSE). Two analysts are hired to model the volume series. The monthly log volume of the NYSE and its change (difference) are plotted in the diagrams below.





(a) One analyst has estimated three models from 537 monthly observations on the *differenced* log volume of the NYSE, $\{\Delta y_t\}$. The estimation results are summarized in the table below, where Δy_t is the dependent (or left hand side) variable.

Estimation Results

Model	Δy_{t-1}	Δy_{t-2}	Δy_{t-3}	ε_{t-1}	c	SSR
AR(2)	-.413	-.218			.016	16.94
	[.042]	[.042]			[.008]	
AR(3)	-.414	-.220	-.005		.016	16.94
	[.043]	[.046]	[.043]		[.008]	
ARMA(1,1)	.346			-.794	.007	16.35
	[.066]			[.043]	[.002]	

The standard errors for estimated coefficients are given in brackets.

(i) Based on the above table, which model would you prefer? Explain briefly. [4 marks]

(ii) Regardless of your answer to (i), use the estimated AR(2) model to make 1-step ahead and 2-step ahead point forecasts for the differenced log volume. It is known that the most recent observations $\Delta y_T = .23$ and $\Delta y_{T-1} = -.15$. [4 marks]

(b) The other analyst has estimated two models from 537 monthly observations on the log volume of the NYSE, $\{y_t\}$. The estimation results are summarized below, where the difference $\Delta y_t = y_t - y_{t-1}$ is the dependent variable.

Estimation Results

Model	y_{t-1}	Δy_{t-1}	Δy_{t-2}	t	c	SSR
Model A	-.141	-.325	-.165	.00147	.391	16.20
	[.029]	[.045]	[.043]	[.00030]	[.078]	
Model B		-.413	-.218	.00001	.013	16.94
		[.042]	[.042]	[.00005]	[.016]	

The standard errors for estimated coefficients are given in brackets.

Based on the above table, should y_{t-1} be included in the model? Explain briefly. [4 marks]

(c) Given the models in (a) and (b), Comment on whether or not a combination of the forecasts from different models may improve forecast performance in this context. [3 marks]

Appendix

Some Notation

- MSFE: mean squared forecast error
- AR: autoregressive
- MA: moving average
- ARMA: autoregressive moving average
- SSR: sum of squared residuals
- ACF: autocorrelation function
- PACF: partial autocorrelation function
- c : constant term of a model
- t : time index
- T : sample size

Useful Formulae

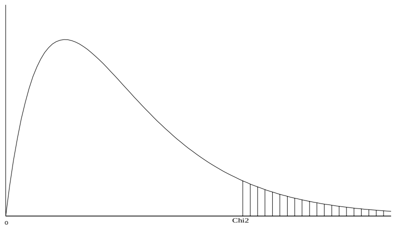
- MA(2*4): $\bar{y}_t = (y_{t-2} + 2y_{t-1} + 2y_t + 2y_{t+1} + y_{t+2})/8$
- $Q_{LB}(m) = T(T+2)\sum_{\tau=1}^{m} \hat{\rho}^2(\tau)/(T-\tau)$
- Exponential smoother: $\bar{y}_t = \alpha y_t + (1-\alpha)\bar{y}_{t-1}, \quad \bar{y}_1 = y_1$
- ARMA(p,q): $x_t = \sum_{i=1}^{p} \phi_i x_{t-i} + \varepsilon_t + \sum_{j=1}^{q} \theta_j \varepsilon_{t-j} + c$
- BIC or SIC: BIC $= \log(\text{SSR}/T) + k\log(T)/T$

Useful Statistical Tables

Dickey-Fuller Critical Values

Level of Significance	1%	2.5%	5%	10%
Critical Value	-3.98	-3.68	-3.42	-3.13

Table 6.
Upper-tail Chi-square Critical Values: χ2(α,ν)



	α									
ν	**0.995**	**0.99**	**0.975**	**0.95**	**0.9**	**0.1**	**0.05**	**0.025**	**0.01**	**0.005**
1	3.93E-05	0.0002	0.0010	0.0039	0.0158	2.7055	3.8415	5.0239	6.6349	7.8794
2	0.0100	0.0201	0.0506	0.1026	0.2107	4.6052	5.9915	7.3778	9.2103	10.5966
3	0.0717	0.1148	0.2158	0.3518	0.5844	6.2514	7.8147	9.3484	11.3449	12.8382
4	0.2070	0.2971	0.4844	0.7107	1.0636	7.7794	9.4877	11.1433	13.2767	14.8603
5	0.4117	0.5543	0.8312	1.1455	1.6103	9.2364	11.0705	12.8325	15.0863	16.7496
6	0.6757	0.8721	1.2373	1.6354	2.2041	10.6446	12.5916	14.4494	16.8119	18.5476
7	0.9893	1.2390	1.6899	2.1673	2.8331	12.0170	14.0671	16.0128	18.4753	20.2777
8	1.3444	1.6465	2.1797	2.7326	3.4895	13.3616	15.5073	17.5345	20.0902	21.9550
9	1.7349	2.0879	2.7004	3.3251	4.1682	14.6837	16.9190	19.0228	21.6660	23.5894
10	2.1559	2.5582	3.2470	3.9403	4.8652	15.9872	18.3070	20.4832	23.2093	25.1882
11	2.6032	3.0535	3.8157	4.5748	5.5778	17.2750	19.6751	21.9200	24.7250	26.7568
12	3.0738	3.5706	4.4038	5.2260	6.3038	18.5493	21.0261	23.3367	26.2170	28.2995
13	3.5650	4.1069	5.0088	5.8919	7.0415	19.8119	22.3620	24.7356	27.6882	29.8195
14	4.0747	4.6604	5.6287	6.5706	7.7895	21.0641	23.6848	26.1189	29.1412	31.3193
15	4.6009	5.2293	6.2621	7.2609	8.5468	22.3071	24.9958	27.4884	30.5779	32.8013
16	5.1422	5.8122	6.9077	7.9616	9.3122	23.5418	26.2962	28.8454	31.9999	34.2672
17	5.6972	6.4078	7.5642	8.6718	10.0852	24.7690	27.5871	30.1910	33.4087	35.7185
18	6.2648	7.0149	8.2307	9.3905	10.8649	25.9894	28.8693	31.5264	34.8053	37.1565
19	6.8440	7.6327	8.9065	10.1170	11.6509	27.2036	30.1435	32.8523	36.1909	38.5823
20	7.4338	8.2604	9.5908	10.8508	12.4426	28.4120	31.4104	34.1696	37.5662	39.9968
21	8.0337	8.8972	10.2829	11.5913	13.2396	29.6151	32.6706	35.4789	38.9322	41.4011
22	8.6427	9.5425	10.9823	12.3380	14.0415	30.8133	33.9244	36.7807	40.2894	42.7957
23	9.2604	10.1957	11.6886	13.0905	14.8480	32.0069	35.1725	38.0756	41.6384	44.1813
24	9.8862	10.8564	12.4012	13.8484	15.6587	33.1962	36.4150	39.3641	42.9798	45.5585
25	10.5197	11.5240	13.1197	14.6114	16.4734	34.3816	37.6525	40.6465	44.3141	46.9279
26	11.1602	12.1981	13.8439	15.3792	17.2919	35.5632	38.8851	41.9232	45.6417	48.2899
27	11.8076	12.8785	14.5734	16.1514	18.1139	36.7412	40.1133	43.1945	46.9629	49.6449
28	12.4613	13.5647	15.3079	16.9279	18.9392	37.9159	41.3371	44.4608	48.2782	50.9934
29	13.1211	14.2565	16.0471	17.7084	19.7677	39.0875	42.5570	45.7223	49.5879	52.3356
30	13.7867	14.9535	16.7908	18.4927	20.5992	40.2560	43.7730	46.9792	50.8922	53.6720
40	20.7065	22.1643	24.4330	26.5093	29.0505	51.8051	55.7585	59.3417	63.6907	66.7660
50	27.9907	29.7067	32.3574	34.7643	37.6886	63.1671	67.5048	71.4202	76.1539	79.4900
60	35.5345	37.4849	40.4817	43.1880	46.4589	74.3970	79.0819	83.2977	88.3794	91.9517
70	43.2752	45.4417	48.7576	51.7393	55.3289	85.5270	90.5312	95.0232	100.4252	104.2149
80	51.1719	53.5401	57.1532	60.3915	64.2778	96.5782	101.8795	106.6286	112.3288	116.3211
90	59.1963	61.7541	65.6466	69.1260	73.2911	107.5650	113.1453	118.1359	124.1163	128.2989
100	67.3276	70.0649	74.2219	77.9295	82.3581	118.4980	124.3421	129.5612	135.8067	140.1695