1. (a) The acf of \( \{ y_t \} \) dies away slowly, more or less linearly. This indicates the presence of trend. Thus it appears that \( \{ y_t \} \) is from a non-stationary process.

(b) There appears to be a cut-off point at lag 2 in the acf of \( \{ \Delta y_t \} \), which indicates that \( \{ \Delta y_t \} \) is from an MA(2) process. To check this, we should use the approximate 95% probability limits for the \( r_\tau, \tau > 2 \) at

\[
\pm 2 \sqrt{\frac{1 + 2(r_1^2 + r_2^2)}{T}},
\]

i.e., at

\[
\pm 2 \sqrt{\frac{1 + 2(0.145^2 + 0.362^2)}{399}},
\]

i.e., at \( \pm 0.114 \). (Note that there are 399 observed differences.) None of the tabulated \( r_\tau, \tau > 2 \) falls outside these limits. This supports the hypothesis of an MA(2) process. Thus it appears that \( \{ y_t \} \) is from an ARIMA(0,1,2) process.
2. The following is an outline of a suggested analysis.

```r
> sheep.rts <- rts(as.vector(sheep), start = 1867)
> ts.plot(sheep.rts, xlab = "", ylab = "", main = "Sheep Pop. in England & Wales:1867 to 1939", las = 1)
> sheep.acf <- acf(sheep.rts, 18)
> dsheep.rts <- diff(sheep.rts)
> dsheep.acf <- acf(dsheep.rts, 18)
> dsheep.pacf <- acf(dsheep.rts, 18, type = "partial")
> library(MASS)
> sheep310 <- arima(sheep.rts, order = c(3, 1, 0))
> sheep310
```

Call:
```
arima(x = sheep.rts, order = c(3, 1, 0))
```

Coefficients:
```
                   ar1        ar2        ar3
 0.4210     -0.2018     -0.3043
```
```
s.e. 0.1193  0.1363  0.1243
```

sigma^2 estimated as 4783: log likelihood = -407.56, aic = 823.12
```r
> tsdiag(sheep310)
```
Notice the use of `as.vector()` function in the first line in order to coerce `matrix` or `data.frame` data into a `vector`, which can then be converted into an `rts` object.

(a) A plot of the data and an examination of the acf, which dies away rather slowly, indicates that there is a trend, so that differencing of the data is probably appropriate.

(b) The following acf and pacf are for the differenced data.
Series: dsheep.rts

ACF

Lag 0 5 10 15
-0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0

Series: dsheep.rts

Partial ACF

Lag 0 5 10 15
-0.2 0.0 0.2
From examination of the acf and pacf, it seems that an AR(3) model might be a reasonable one to try for the differenced data, i.e., an ARIMA(3,1,0) model for the undifferenced data. (Note that 95% probability limits appropriate to the differenced data are given by $\pm 2/\sqrt{T} = \pm 2/\sqrt{72} = \pm 0.236$.) The freak significant values at lag 17 need not be taken too seriously – they seem to reflect the fact that there happen to be peaks in the sheep population at intervals of 17 years.

Nothing is indicated by the goodness-of-fit diagnostics which suggests that the ARIMA(3,1,0) model (which has no process mean included) is inappropriate.

The fitted model equation is

$$\Delta Y_t = 0.4210 \Delta Y_{t-1} - 0.2018 \Delta Y_{t-2} - 0.3043 \Delta Y_{t-3} + \epsilon_t,$$

i.e.,

$$Y_t = 1.4210 Y_{t-1} - 0.6228 Y_{t-2} - 0.1025 Y_{t-3} + 0.3043 Y_{t-4} + \epsilon_t.$$