# DEPARTMENT OF PHYSICS & ASTRONOMY
# 3459 EXAM-2
# 10:00 - 13:00 : March 19$^{th}$ 2007

Please read the exam guidelines, rules, instructions and marking criteria at:
`http://www.hep.ucl.ac.uk/undergrad/3459/exam/final.html`
This exam is worth 50% of your final course grade. The duration of the exam is 3 hours. Students should upload their work using the web-form. A breakdown of the mark scheme is indicated.

Ultra high energy neutrinos ($E > 10^{18}$ eV) can be detected by an acoustic signal produced when the neutrinos interact with water. The acoustic signal is recorded by a hydrophone as a set of pressure readings taken over a certain period of time.

The URL:
`http://www.hep.ucl.ac.uk/undergrad/3459/exam/hd_data.dat`
has a line for each hydrophone of the form:

```
H_NAME T_START DT P1 P2 P3 P4 ......  PN
```

where `H_NAME` is the name of the hydrophone, `T_START` is the time at which the first pressure reading, `P1`, was taken and `DT` is the time interval between pressure readings such that pressure reading `PN` is recorded at a time = `T_START + (N-1)*DT`. `T_START` and `DT` are measured in micro-seconds and `PN` in kPa. Data for a given hydrophone may appear more than once, corresponding to data taken at a different time.

The signal recorded by the hydrophone also has a "background" contribution from electronic noise that must be subtracted from the above readings. The background level for each hydrophone may differ and can be determined from the URL:
`http://www.hep.ucl.ac.uk/undergrad/3459/exam/hd_bgd.dat`

The URL has the same form as the `hd_data.dat` URL ie

```
H_NAME T_START DT PB1 PB2 PB3 PB4 ......  PBN
```

where `PB1, PB2, ...  PBN` are background pressure readings for each hydrophone. `N` may not be the same for each hydrophone. Each hydrophone only has one set of background readings.

There are various algorithms that can be deployed to remove the background contribution from the data and to define the intensity of the signal once the background has been subtracted and to define whether a hydrophone is faulty or not.

The simplest algorithm, `ALGO-1`, and the one you will implement first is defined as follows. The signal value for the N$^{th}$ pressure reading, `PN`, is given by `PN_SIG = Math.max(0.0,PN-MEAN(PB1...PBN))`, where `MEAN(PB1...PBN)` is the average of the background readings for a given hydrophone. The intensity is the sum of all non zero `PN_SIG` values. A faulty hydrophone is one where $<$ 50% of the `PN_SIG` values are positive. The mean time of the signal is the mean of the time values for which `PN_SIG` $> 0$.

**PLEASE TURN OVER**

- Determine which hydrophone, as defined by `ALGO-1`, is faulty. [**30/50 marks**]
- Determine which hydrophone, as defined by `ALGO-1`, has the highest intensity neutrino signal [**5/50 marks**]
- Determine the mean time at which the highest signal occurs [**5/50 marks**]

Modify your existing code and define appropriate interfaces so that it could implement different algorithms for subtracting the background, defining the intensity, defining the mean time and whether a hydrophone is faulty or not e.g. an algorithm may define a signal with reference to the mean and RMS of the background signal and a mean time as a weighted mean where each time value is weighted by the signal pressure. [**10/50 marks**]

# END OF PAPER