APhO
HANGZHOU CHINA

16th ASIAN PHYSICS OLYMPIAD 2015
3rd-11th MAY, HANGZHOU, CHINA

Experimental Competition

May 7, 2015

08:30-13:30 hours

Answer Sheets Cover Page

STUDENT CODE

Additional number of writing sheets=

Do not write below this line

	Part A	Part B	Part C	Part D	Part E	Total
Maximum marks	3.0	4.5	4.0	6.5	2.0	20.0
Marks scored						

16th ASIAN PHYSICS OLYMPIAD 2015
3rd-11th MAY, HANGZHOU, CHINA

Country:		Student Code:	

Experiment A

A1.	Choose a PZT plate and use the Vernier caliper to measure its length l, width w, and thickness t. Use the electronic weighing scale to measure its mass m. Use the DMM and the Kelvin clip to measure its capacitance C (at ambient temperature). Considering the slight non-uniformity in the dimensions of the PZT plate and the uncertainties of instrumental readings, repeat each measurement several times and then calculate the mean and the standard error.	1.6pts

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A2.	Now calculate the density ρ and the relative permittivity ε_r of the PZT plate. Based on standard errors obtained from A.1, carry out the error analysis to estimate the uncertainties of ρ and ε_r (vacuum permittivity ε_0 =8.85×10^{-12} F/m).	1.4pts

Country:		Student Code:	

Experiment B

B.1	Prove that the equivalent circuit has a resonant frequency f_r and an antiresonant frequency f_a.	0.9pts

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B.2	Derive d from f_r, f_a and other known parameters of the PZT plate.	0.5pts

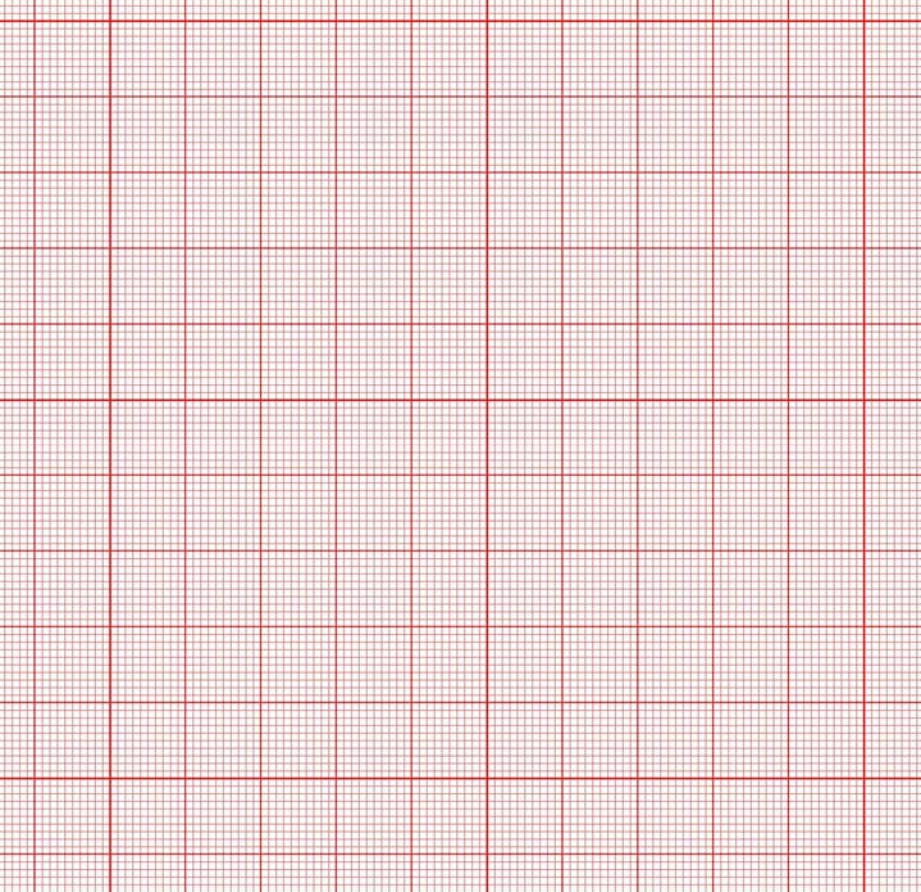16th ASIAN PHYSICS OLYMPIAD 2015
3rd-11th MAY, HANGZHOU, CHINA

Country:		Student Code:	

B.3	Measure the AC current I through the PZT plate as a function of the signal frequency f. Draw the I-f curve and find the resonant frequency f_r and the antiresonant frequency f_a. Calculate the piezoelectric coefficient d accordingly.	3.1pts

16th ASIAN PHYSICS OLYMPIAD 2015
3rd-11th MAY, HANGZHOU, CHINA

Country:		Student Code:	

16th ASIAN PHYSICS OLYMPIAD 2015
3rd-11th MAY, HANGZHOU, CHINA

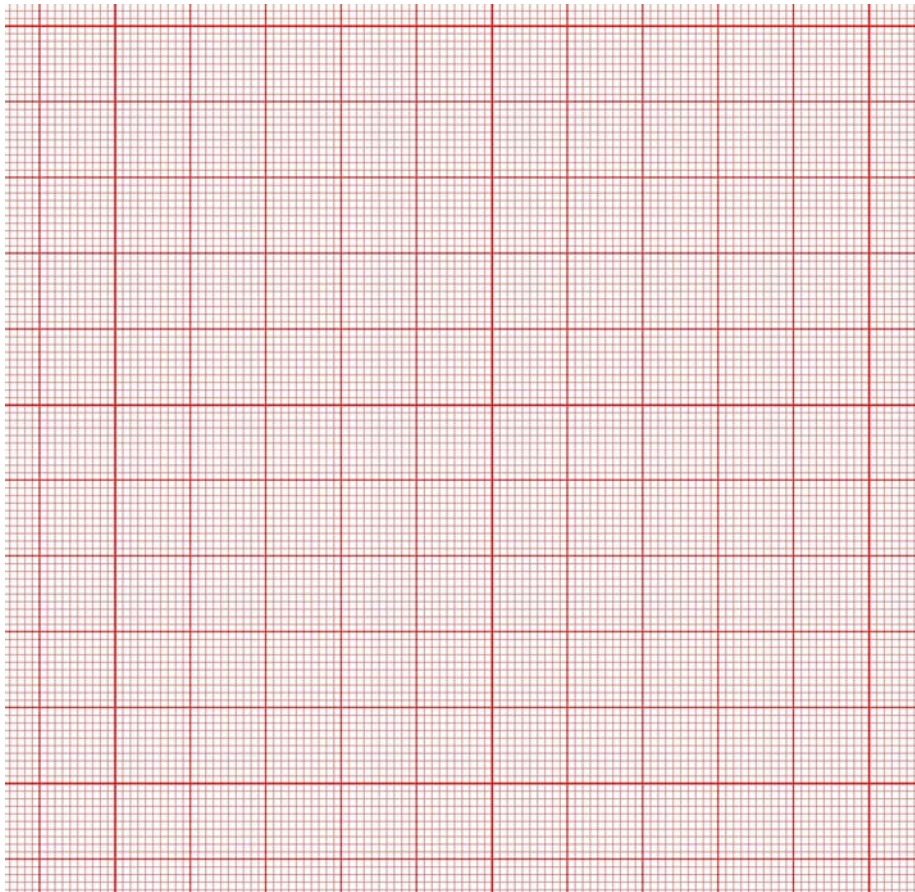| Country:		Student Code:	

Experiment C

C.1	Now measure the capacitance of the PZT plate at various temperatures and record the data.	1.5pts

16th ASIAN PHYSICS OLYMPIAD 2015
3rd-11th MAY, HANGZHOU, CHINA

Country:		Student Code:	

C.2	Analyze the data, draw a proper plot and calculate the Curie temperature accordingly.	2.5pts

Country:		Student Code:	

16th ASIAN PHYSICS OLYMPIAD 2015
3rd-11th MAY, HANGZHOU, CHINA

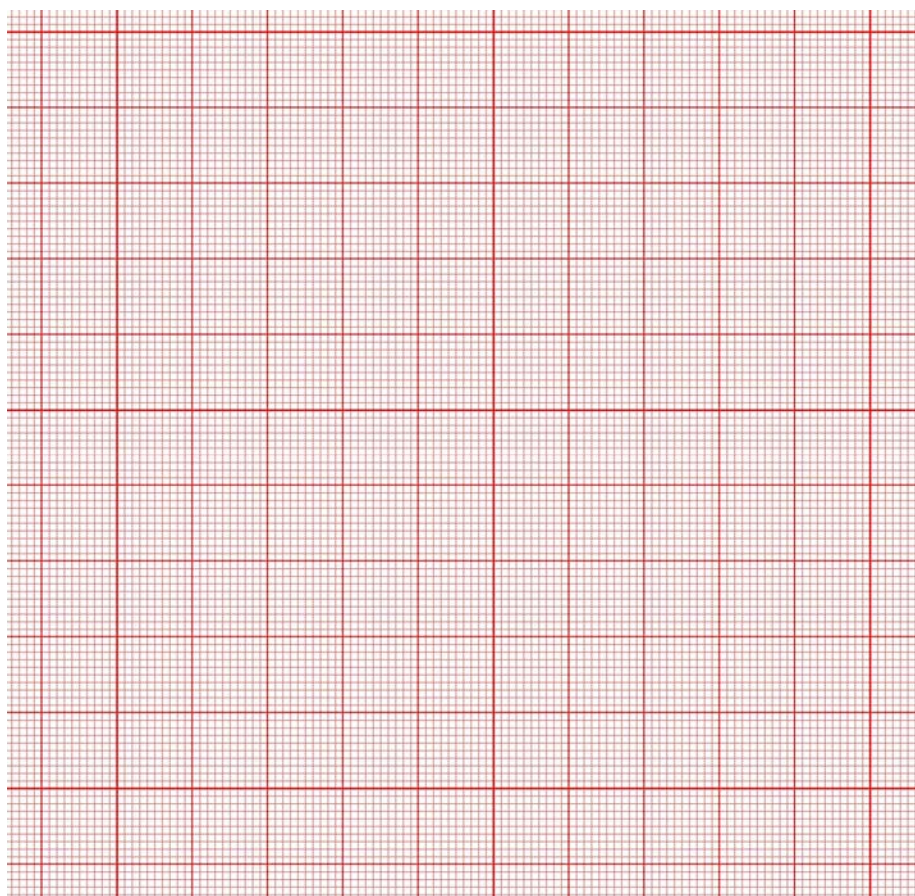| Country:		Student Code:	

Experiment D

D.1	Assume that the length of the aluminum rod is L and the wave velocity is u. Under the free boundary condition, derive the equation for the frequencies f_n of the standing (resonant) waves along the long rod. Then derive the equation for the wave velocity u from f_n.	0.6pts

16th ASIAN PHYSICS OLYMPIAD 2015
3rd-11th MAY, HANGZHOU, CHINA

| Country: | | Student Code: | |

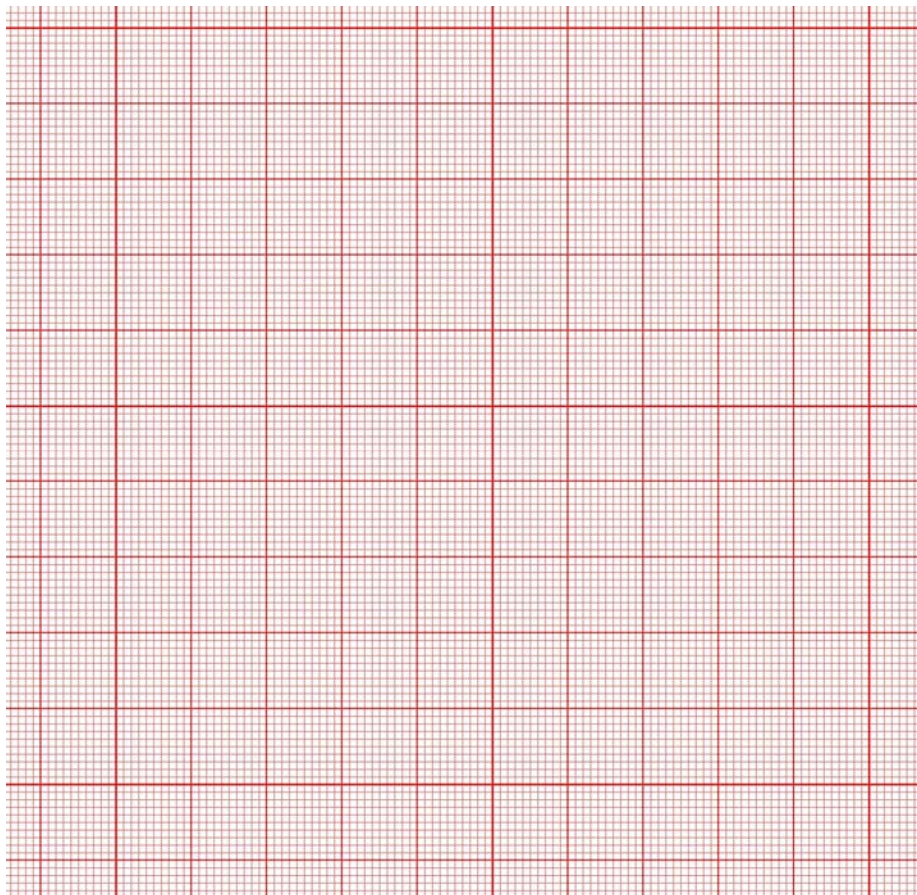| D.2 | Use the steel tape measure to read the length L of the aluminum rod. Please repeat the measurement several times and calculate the mean and the standard error. | 1.6pts |
| | While changing the frequency of the sound waves produced by the transducer, record the peak values monitored by the sensor. Draw a spectrum containing all measured resonant peaks, similar to that shown in Figure 12. | |

16th ASIAN PHYSICS OLYMPIAD 2015
3rd-11th MAY, HANGZHOU, CHINA

Country:		Student Code:	

D.3	Identify the resonant peaks likely resulting from the transverse waves. Calculate the transverse wave velocity accordingly and carry out the error analysis. Attention: there might be irrelevant peaks caused by imperfection of the experimental setup, e.g., imperfect free boundary condition. You need to make a judgement and ignore the irrelevant peaks during your analysis.	1.4pts

16th ASIAN PHYSICS OLYMPIAD 2015
3rd-11th MAY, HANGZHOU, CHINA

Country:		Student Code:	

D.4	While changing the frequency of the sound waves produced by the transducer, record the peak values monitored by the sensor. Draw a spectrum containing all measured resonant peaks, similar to that shown in Figure 12.	1.5pts

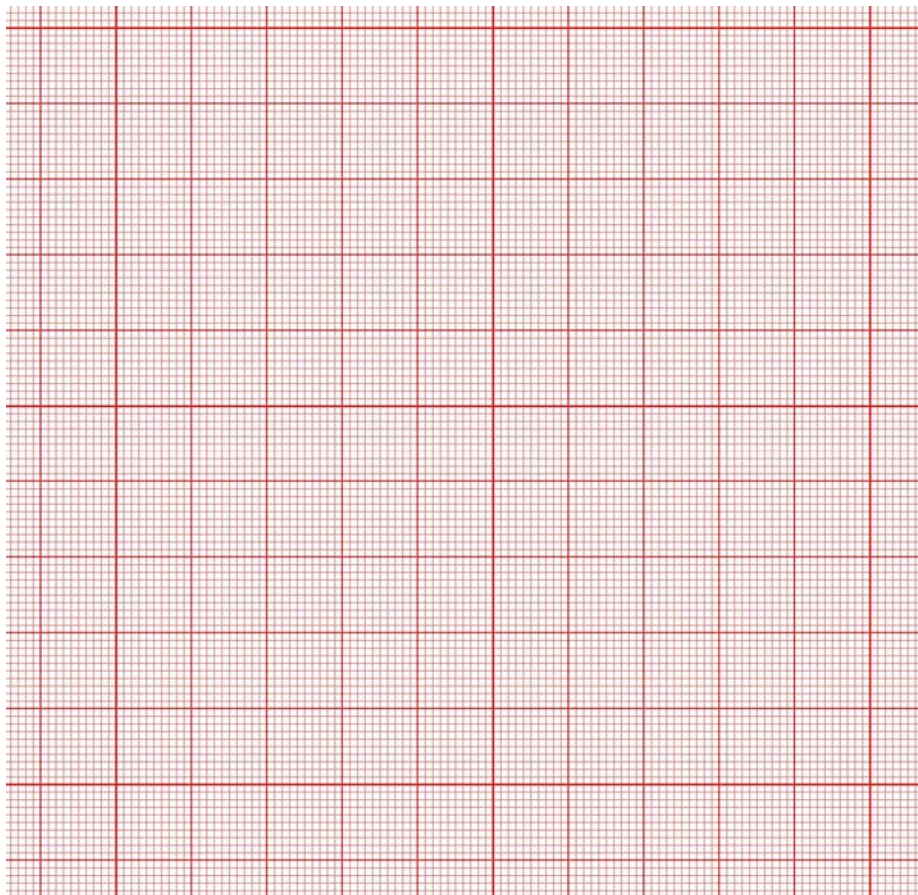16th ASIAN PHYSICS OLYMPIAD 2015
3rd-11th MAY, HANGZHOU, CHINA

Country:		Student Code:	

D.5	Compare with the result in D.2, identify the resonant peaks caused by the transverse waves. Select the resonant peaks resulting from the longitudinal waves and calculate the longitudinal wave velocity accordingly. Carry out the error analysis.	1.4pts

16th ASIAN PHYSICS OLYMPIAD 2015
3rd-11th MAY, HANGZHOU, CHINA

Country:		Student Code:	

Experiment E

E.1	While changing the frequency of the sound waves produced by the transducer, record the peak values monitored by the sensor. Draw a spectrum containing all measured resonant peaks, similar to that shown in Figure 12.	1.2pts

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E.2	In the measured spectrum, identify the resonant peaks corresponding to the existence of the deep cut. Estimate the distance from the spot of the cut to the end of the rod that is in contact with the PZT plates.	0.8pts