Name: ________________________________ (   )   Class: _________

華僑中學
HWA CHONG INSTITUTION
SAMPLE D

HIGHER PHYSICS

Level : Secondary Three
Duration : 1 hour

INSTRUCTIONS TO CANDIDATES

Do not open this booklet until you are told to do so.

Write your name, index number and class on the top of this page.

Answer the questions in **Section A and B** in the spaces provided. All workings must be shown.

In **Section B**, answer only **2 questions** out of the 3 questions.

INFORMATION FOR CANDIDATES

In **Sections A and B,** the intended marks for each question or part of a question are given in brackets [ ]. Any working should be done in the space provided.

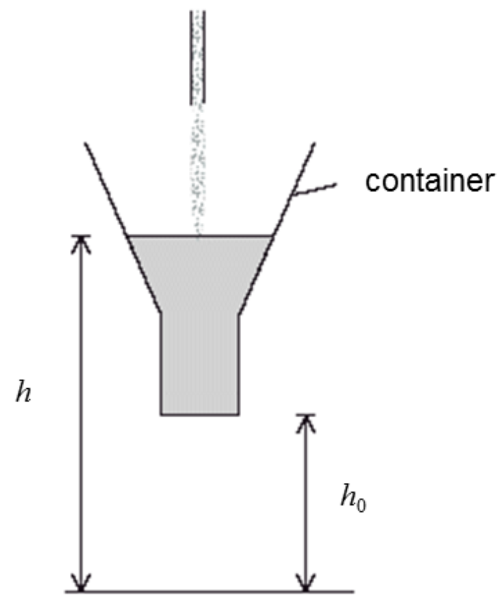
When necessary, take acceleration due to gravity, **g** to be 10 m s^{-2}.

This question paper consists of 12 printed pages, including this page.

Section A [20 marks]

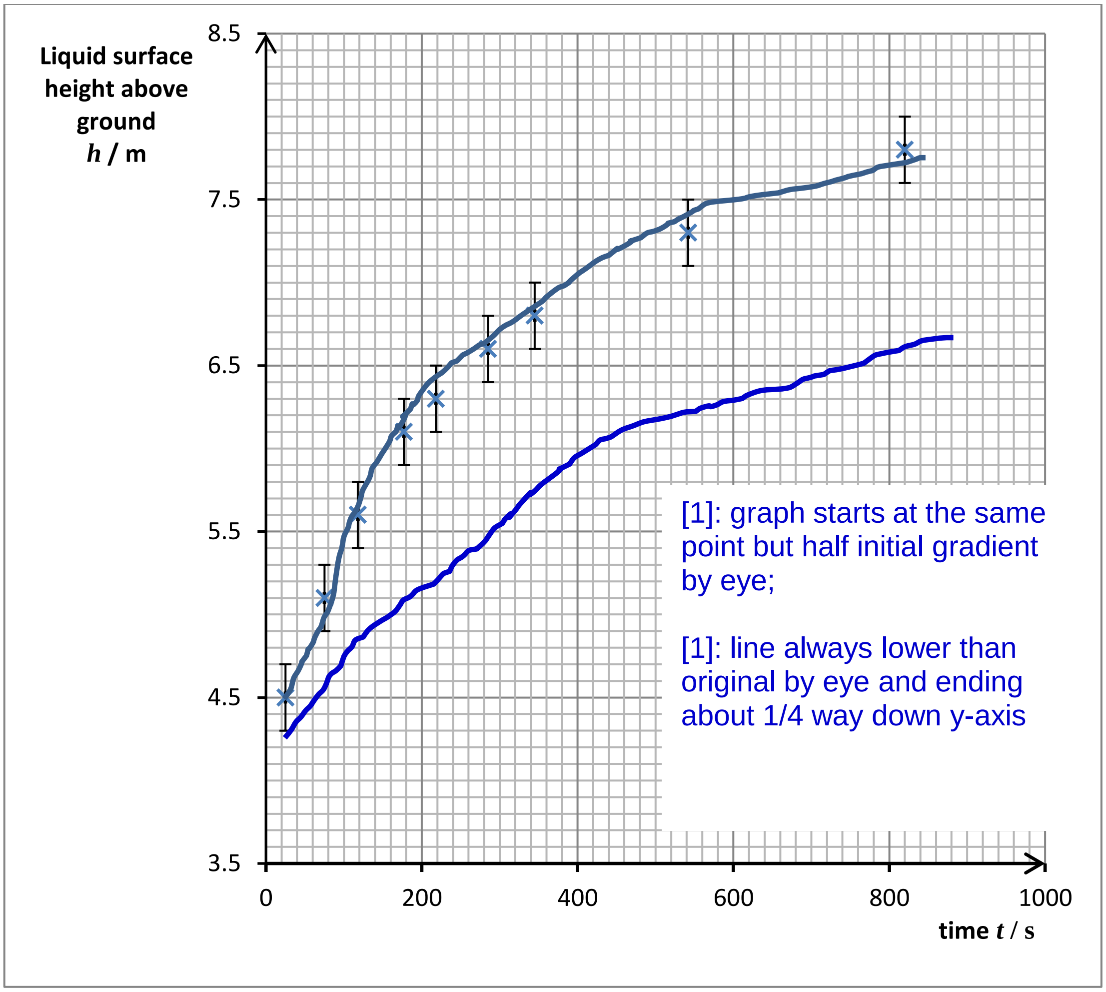
1 This question is about liquid flow.

The diagram shows a storage container for liquids.



The container is filled from above. The distance between the base of the container and the ground is h_0.

The initially empty container is then filled at a constant rate. The height h of the liquid surface above the ground is measured as a function of time t. The results of the measurements are shown plotted on the following page.



(a) Draw a best-fit line for the data. [1]: Line going through each error bar [1]

(b) It is hypothesized that h is directly proportional to t. State and explain whether this hypothesis is correct for the periods

(i) $t = 0$ to $t = 120$ s.

[1]: line does not go through (0,0) / origin. Hence, no.

[1]

(ii) $t > 120$ s.

[1]: line is curved / gradient, not constant. Hence, no

[1]

(c) Use data from the graph to determine the value of h_0.

[1]: line is drawn to find intercept on the y-axis

[1]: 4.2 ± 0.1 m

[2]

(d) The area of the base of the container is 1.8 m^2. Deduce that the volume of liquid entering the storage container each second is approximately 0.02 m^{3}s^{-1}.

large (at least half of line) triangle from a straight-line portion of the graph

[1]: slope $= 0.012(\pm 0.001)\ (\text{ms}^{-1})$

[1]: volume per second $= area \times slope = 0.022\ \text{m}^3\text{s}^{-1}$

Alternatively,

determines height difference over time range within 0 and 120 s

$$\text{volume per second} = \frac{1.8 \times (\text{difference in heights})}{\text{time between heights}} = 0.022\ \text{m}^3\text{s}^{-1}$$

[2]

(e) The container is filled after 850 s. Calculate the total volume of the container.

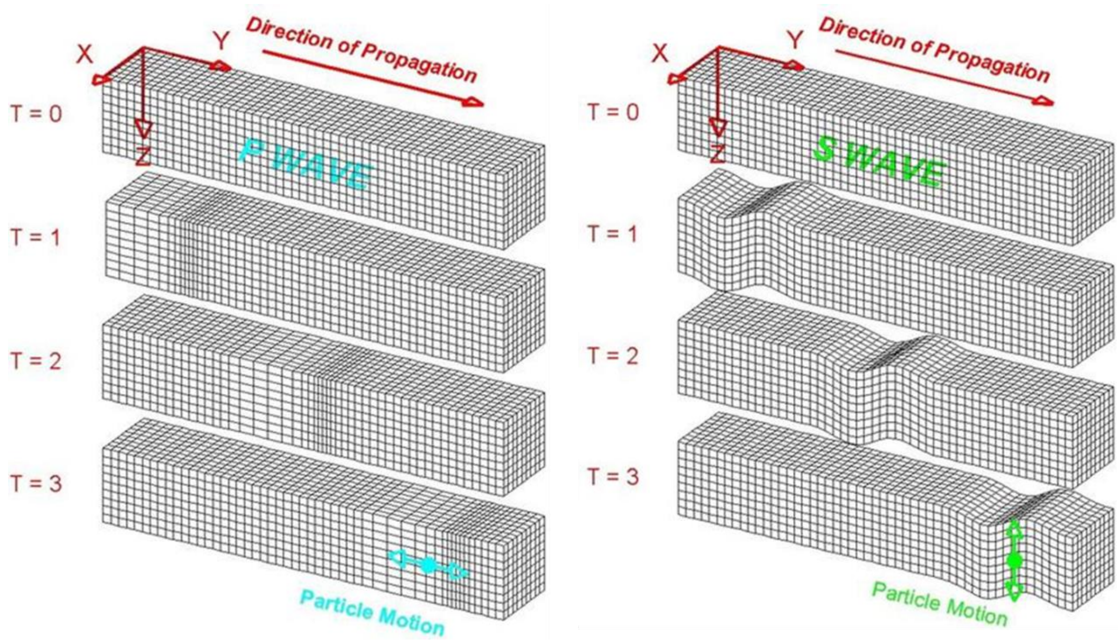
$(850 \times 0.022) = 19\ \text{m}^3$ or $(850 \times 0.02) = 17\ \text{m}^3$

Volume = ... m^3 [1]

(f) The empty container is now filled at half the rate in **(d)**. Using the same axes on page 3, sketch a graph to show the variation of h with t in the range $t = 0$ to $t = 900$ s. [2]

2 This question is about waves in earthquakes.

P and **S** waves are waves associated with earthquakes. A **P** wave is a *compressional* wave. The disturbance travels longitudinally with the particle motion. An **S** wave is a *shear* wave because the particle motion is perpendicular to the direction of wave travel. (see the picture below)



Longitudinal **P** wave　　　　Transverse **S** wave

In an earthquake, a **P** wave and an **S** wave travel at different speeds, and we can use this difference to help us locate the 'epicentre' of the earthquake (where the disturbance took place).

(a) Assuming typical speeds of 8.5 km s^{-1} and 5.5 km s^{-1} for **P** and **S** waves, respectively, how far away did an earthquake occur if a particular seismic station detects the arrival of these two types of waves 1.5 minutes apart?

[1]: conversion of units to be consistent, e.g. 1.5 min to 90 s

[1]: Let t be the time taken for the **P** wave and $90-t$ time taken for the **S** wave

$$v_{\text{P wave}}(t_1)=v_{\text{S wave}}(90-t_1)$$

[1]: $(8500)(t_1)=(5500)(90-t_1)$

[1]: $t_1 = 35.36$ s

[1]: Distance from earthquake $= 8500 \times 35.36 = 3.0 \times 10^5$ m

Solution by graphical methods, i.e. using geometrical shapes to determine areas under $v-t$ graphs, are accepted.

distance from epicentre = ………………………………….. m [5]

(b) Is one seismic station sufficient to determine the position of the epicentre? If yes, explain your reasoning. If not, suggest the minimum number of stations needed to determine the epicentre position and explain your reason.

You may use the space below to draw diagrams for your explanation.

[1]: minimum 3 stations are needed.

[1]: idea of distance in (a) provide a locus of radius 3.0×10^5 m

[1]: idea that a minimum of three circles are needed for a specific intersection point.

[3]

(c) **P** waves tend to shake buildings vertically (up and down), while **S** waves tend to cause buildings to shake horizontally (left and right). This wave is not the same as the drawings on page 5 because the waves are deep inside the Earth and not surface waves.

State and explain which type of wave is more damaging.

[1]: **S** waves

[1]: Buildings are built to withstand weight which is acting vertically and not necessarily in vertical direction.

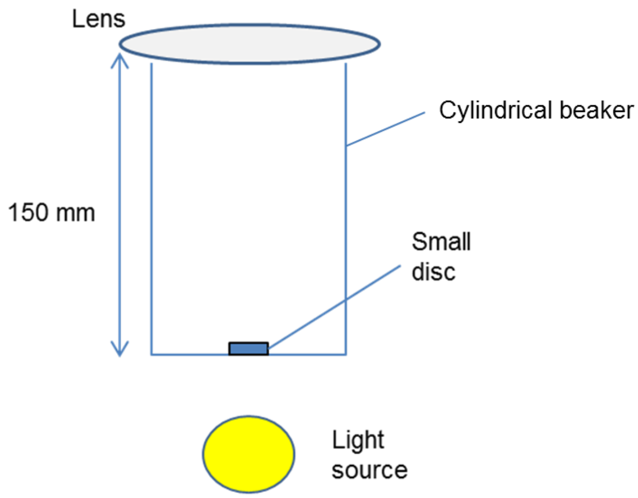
[2]

Section B [20 marks]

Answer two out of three questions in this section.

3 This question is about optics.

A small disc, 6 mm in diameter, lies centrally at the bottom of a cylindrical beaker of height 150 mm and is illuminated from below. A converging lens of focal length 100 mm rests on the rim of the beaker and forms an image of the disc. You can assume that the lens is thin.



(a) Determine, by calculation or otherwise, the image distance of the disc.

[1]: $\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \quad \Rightarrow \quad \frac{1}{100} = \frac{1}{150} + \frac{1}{v}$

[1]: $v = 300$ mm

Image distance = …………………….. mm [2]

(b) The beaker is now filled with water to a height h. Derive an equation, in terms of h, for the effective object distance.

Take the refractive index of water to be $\frac{4}{3}$.

[1]: $n = \frac{\text{Real depth}}{\text{Apparent depth}} = \frac{4}{3} \quad \Rightarrow \quad \text{Apparent depth} = \frac{3}{4} \times \text{Real depth} = \frac{3}{4}h$

[1]: Object position is elevated by $\frac{1}{4}h$

[1]: $\text{Effective object distance} = 150 - \frac{1}{4}h$

[3]

(c) Based on the equation that you have worked out in **(b)**, explain whether it is possible to form a virtual image for this set-up.

[1]: $\text{minimum effective object distance} = \frac{3}{4}h = 112.5 \text{ mm}$

[1]: larger than the focal length, hence no

ecf permitted for this question

[2]

(d) When the water level is at half the beaker's height, the image appears at a distance of 420 mm away from the lens. Calculate the diameter of the new image.

[1]: $\text{Magnification, M} = \left|\frac{v}{u}\right| = \frac{420}{150 - \frac{1}{4}(0.5 \times 150)}$

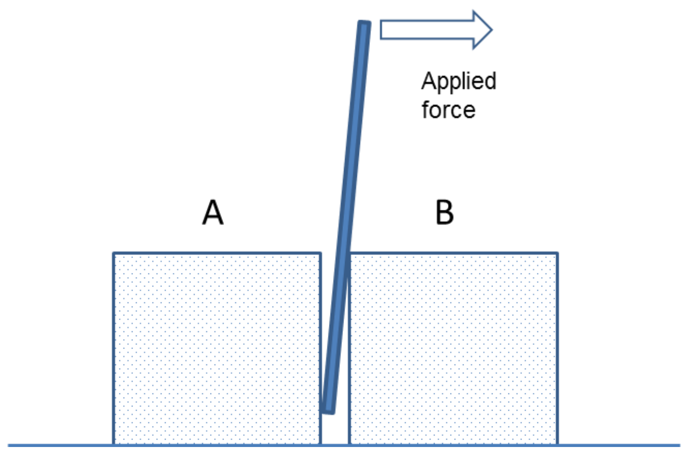
[1]: $\text{Image size} = \text{M} \times \text{object size} = \frac{420}{150 - \frac{1}{4}(0.5 \times 150)} \times (6 \text{ mm})$

[1]: $= 19.2 \text{ mm}$

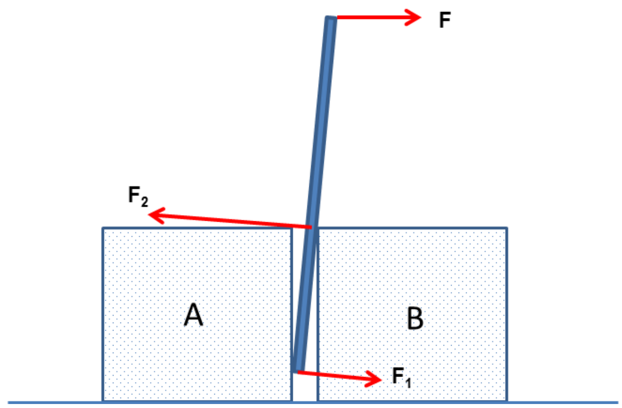
Image diameter = …………………. mm [3]

4 This question is about forces and motion.

(a) Two identical boxes, A and B, stand on a floor with two sides parallel and only a few cm apart, as shown. Insert a long stiff pole vertically in the space between the boxes and pull horizontally at the upper end of the pole to separate the boxes.



Will both boxes move simultaneously or just one of them? If it is one of them, which box is it? In any case, explain your answer. You may use the space below for mathematical working or diagrammatic reasoning.



[1]: The lower end of pole presses on A and creates contact force $\mathbf{F}_1$;

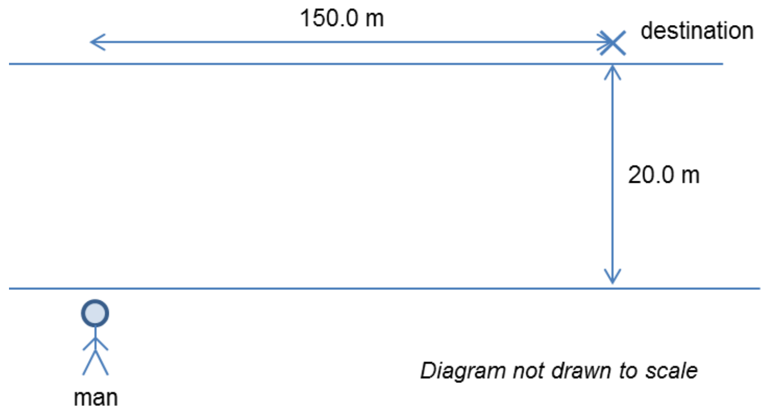
[1]: By Newton's 3rd law, box A presses back on pole with $\mathbf{F}_1$;

[1]: No net force on pole $\Rightarrow$ $\mathbf{F}_2 = \mathbf{F} + \mathbf{F}_1$ or $\mathbf{F}_2 > \mathbf{F}_1$

[1]: $\Rightarrow$ Box B will move

[4]

(b) A man standing on the south bank of a still river of width 20.0 m. He can run at a top speed of 10.0 ms^{-1} and swim at 2.0 ms^{-1}. His destination is a point 150.0 m downstream on the north bank.



Calculate the distance that he should swim and the distance he should run to reach the destination in the shortest time.

Hint: Consider a critically refracted ray

[1]: $\frac{v_{run}}{v_{swim}} = \frac{1}{\sin c} = \frac{10}{2}$

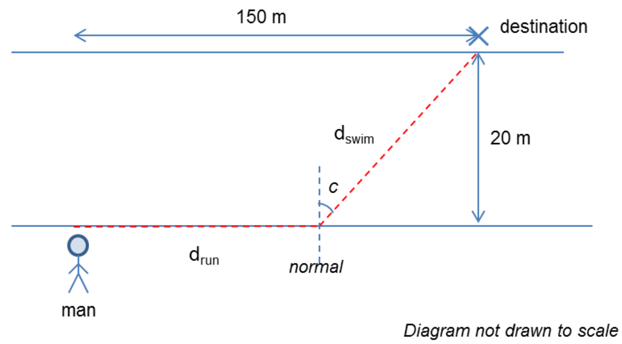
[1]: $\Rightarrow c = 11.54^\circ$

[1]: $d_{swim} = \frac{20}{\cos c} = \frac{20}{\cos 11.54^\circ}$

[1]: $= 20.4$ m

[1]: $d_{run} = 150 - \sqrt{20.41^2 - 20^2}$

[1]: = 146 m

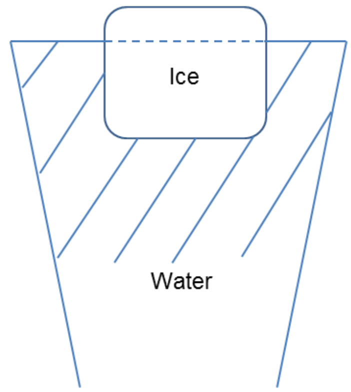


Swimming distance = ……………………… m [4]

Running distance = ……………………… m [2]

5 This question is about density and thermal physics.

(a) An ice cube floats on a cup of water filled to the brim, as shown. As ice is slightly less dense than water, a small part of the ice cube will float above the surface. In ancient Greece, Archimedes found a principle that a floating object has the same weight as the amount of fluid it displaces.



(i) Explain whether the water will spill over the brim as the ice cube melts. Assume thermal contraction of water is negligible.

[1]: Weight of ice = weight of liquid water displaced (Archimedes' principle)

[1]: same weight $\Rightarrow$, same volume for the same state

[1]: Water level remains constant when the ice melts

[3]

(ii) If the original ice cube has air bubbles trapped inside it, then a greater portion of the ice cube will be above the water surface compared to **(a)(i)**. When this air-bubbled ice cube melts, **explain** whether the water level will rise, drop or remain at the same level.

[1]: Weight of (ice + air bubbles) = weight of liquid water displaced

[1]: ice melts to the same volume as water displaced

[1]: air from bubbles remain floating above the water surface $\Rightarrow$ no difference in water level

Accept air density is insignificant compared to liquid water

[3]

(b) In 1895, the first large-scale hydroelectric power plant was installed at Niagara Falls, New York, and by 1900 there were 10 generators, rated at 5000 horsepower each.

(i) In terms of *energy conversion*, explain how an ideal hydroelectric power plant works.

[1]: GPE from water turns to KE to drive turbines which in turn drives the generator

[1]: In generator, KE is turned into electrical energy

[2]

(ii) Suppose all the electric power is fed to a giant electric heater at the exit tube of the generator. Will that power be sufficient to bring the water close to boiling point? Explain.

[1]: At best, energy supplied to water is equal to the KE converted to thermal if it is falling freely

[1]: since no waterfalls have been reported to have hot water at the bottom of the fall, hence no

[2]

END OF PAPER