O Level Pure Physics Structured

Pressure Test 1.0

Q1

Fig. 3.1 shows a diver salvaging items from a plane wreck below the surface of a lake. The density of the water in the lake is 1000 kg/m^3, the atmospheric pressure at the surface is 1.0×10^5 Pa and the gravitational field strength is 10 N / kg. The diver inflates a balloon with air at a depth of 15 m and attaches the balloon to a tray of object.

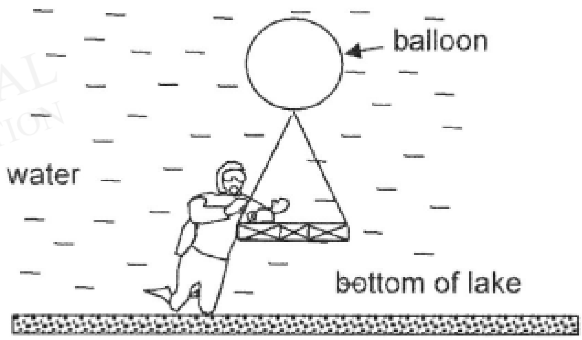

Fig. 3.1

(a) Calculate

(i) the pressure due to 15 m of water in Pa,

pressure = ... [2]

(ii) the total pressure at 15 m below the surface of the lake.

pressure = ... [1]

(b) The pressure of the air inside the balloon is lower at the surface of the lake than at a depth of 15 m. Explain, in terms of the air molecules inside the balloon, why the pressure is lower. State any assumption(s) made.

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.... [2]

(c) State one difference between the arrangement of the molecules of water in the lake and the molecules of air in the balloon.

....

.... [1]

Q2

(a) Fig. 4.1 shows a simplified form of the hydraulic press, also known as a force multiplier. The small piston has a cross-sectional area of 30.0 cm^2 and the large piston has a cross-sectional area of 0.15 m^2. An applied force, 4.0 N, is acting on the small piston to maintain the position of the load shown.

(Neglect the weight of the pistons and the hydrostatic pressure variation.)

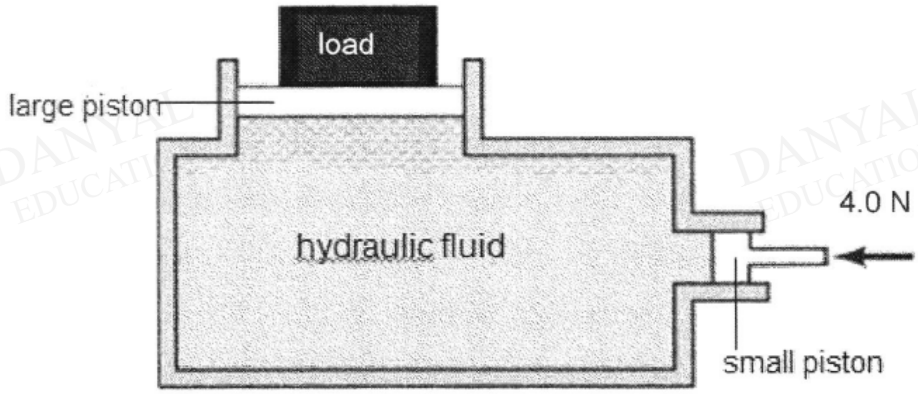

Fig. 4.1

(i) Calculate the weight of the load. **[2]**

(ii) State, if any, to the motion of the large piston is the cross-sectional area of large piston is increased while the weight is still as what is calculated in (i). **[1]**

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(iii) Suggest why the hydraulic press will not function well if the fluid is changed into air. **[1]**

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(b) Fig 4.2 shows the landscape of a mountain. The reading of a mercury barometer at the foot of the mountain is 76.0 cmHg.

On point **P** of the mountain, its reading drops to 70.0 cmHg. The density of mercury is 13 600 kg/m^3 and the density of air is 1.23 kg/m^3.

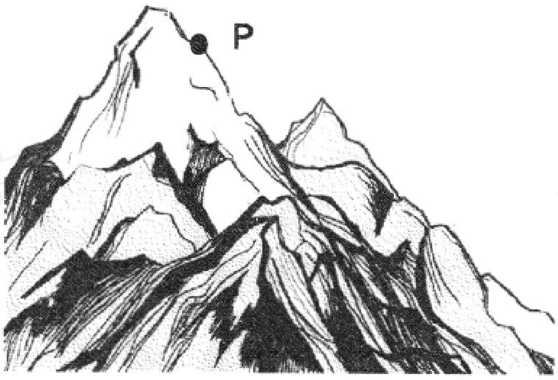

Fig. 4.2

(i) Calculate the height of the mountain. **[3]**

(ii) Water is heated up at point **P**. State and explain if the water is able to boil at 100 °C. **[2]**

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Q3

Fig. 10.1 shows an air pump, which is 1.0 m in length, connected to a manometer. It initially contains 2000 cm^3 of air at atmospheric pressure of 1.03×10^5 Pa. The volume of air in the narrow tube is negligible. The right side of the manometer is exposed to atmospheric pressure.

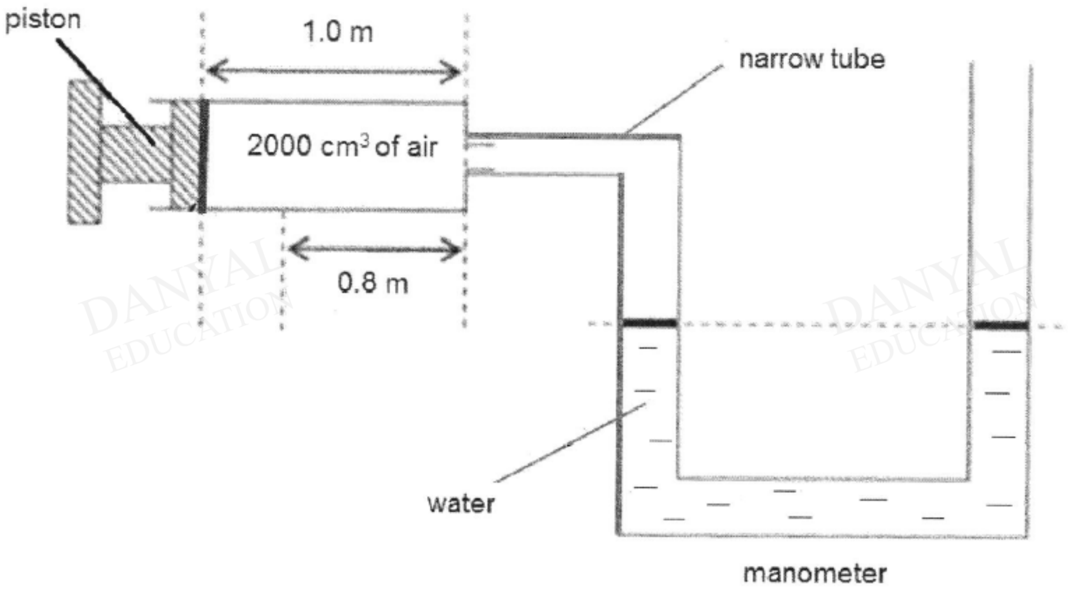

Fig. 10.1

The piston is partially pushed to the right and held steady at a distance of 0.8 m as indicated in Fig. 10.1. The temperature of the air inside the air pump remains constant.

(a) Describe the difference in the motion of the air molecules in the air pump and the water molecules in the manometer.

....

....

....[2]

(b) The cross-sectional area of the piston is 2×10^{-3} m^2.

Calculate the force of air acting on the piston before it was pushed.

force = ...[2]

(c) Using ideas about molecules, explain why the pressure of the air inside the air pump increases when the piston is pushed.

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....

....

....[3]

(d) After the piston was pushed, the pressure in the air pump increases to 1.29×10^5 Pa.

The density of water is 1000 kg/m^3 and gravitational field strength is 10 N/kg.

Calculate the height difference between the water columns in the manometer.

height difference = ...[2]

(e) Explain why there is no change to the height difference between the water columns in the manometer in **(d)** if the diameter of the manometer tubing is increased.

....[1]

Q4

Fig. 14.1 shows a "My Fun Fish Cleaning Tank" that is sold at Toysrus. The product description is as follows, "MY FUN FISH™ —THE AQUARIUM THAT CLEANS ITSELF! Kids and parents alike will love this easy-care, light-up fish tank that works like magic! The secret is gravity clean technology—just pour clean water in; dirty water automatically flushes out from a specially-designed reservoir as fresh water is added. No filters, no cords, and no need to remove fish or decorations from the tank!"

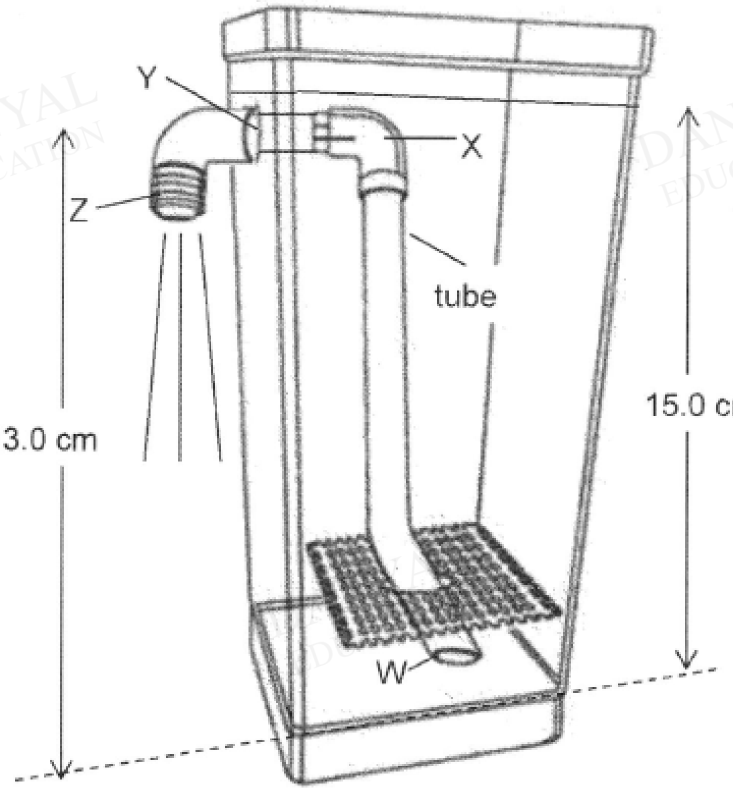

Fig. 14.1

Jessica wants to clean her tank now. She pours in water so that the water level is 15.0 cm from the base of the tank. Dirty water is seen flowing from positions W, X, Y to Z of the tube. Positions X and Y of the tube are at the same vertical height and are 13.0 cm from the base of the tank.

The density of water is 1000 kg/m^3. Atmospheric pressure is 10^5 Pa.

(a) Explain *pressure is 10^5 Pa*.

....

.... [1]

(b) Calculate the pressure at the base of the aquarium when the water level is 15.0 cm from the base of the tank.

pressure = ... [2]

(c) Explain why water flows out of the tank when the water level is 15.0 cm from the base of the tank. You may use the positions W, X, Y, or Z of the tube to explain your answer.

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.... [3]

(d) State the position of the water level in the tank so that water will just not flow out of the tank.

....

.... [1]

Q5

In an experiment to investigate Bernoulli's Principle on a wing of an aircraft, the effects of air velocity and pressure are recorded as the aircraft moves through air.

Fig. 10.1 shows how the air flow passes the wing. The velocity of air above the wing is higher than the velocity of air below the wing.

The pressure and velocity data of the aircraft and air (above and below the wing) are recorded in Fig. 10.3.

Bernoulli's Principle explains why there is a pressure difference above and below the wings (see Fig. 10.2), which produces lift.
Lift is an upward force produced on the wings of an aircraft, allowing it to take off from a runway.

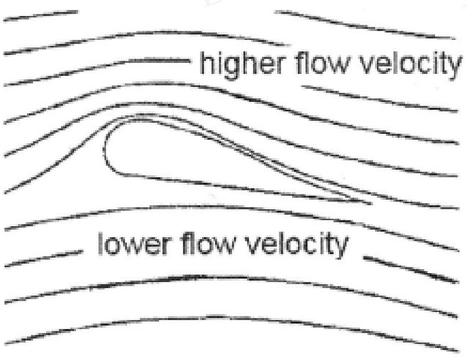

Fig. 10.1

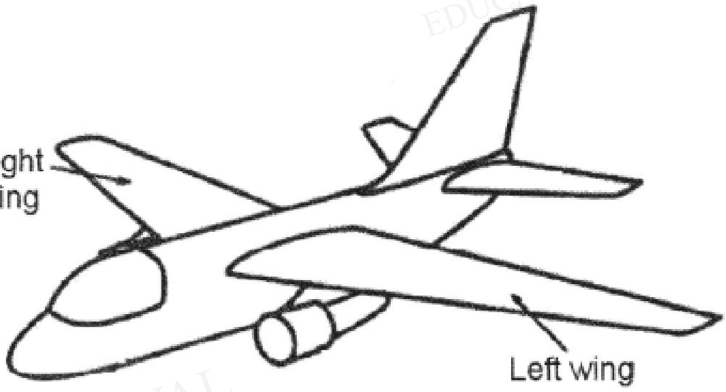

Fig. 10.2
(Image from Google)

	Aircraft Speed / ms^{-1}	30.0	40.0	50.0	60.0	70.0	80.0
Above both wings	**Air Velocity / ms^{-1}**	36.0	48.0	60.0	72.0	84.0	96.0
	Air Pressure / Pa	551	980	1531	2205	3001	3920
Below both wings	**Air Velocity / ms^{-1}**	30.0	40.0	50.0	60.0	70.0	80.0
	Air Pressure / Pa	794	1411	2205	3175	4322	5645

Fig. 10.3

(a) Based on the data provided above, state the relationship between the speed of the aircraft and the air pressure difference above and below the wing.

.... [1]

(b) Bernoulli's Principle is essential for the production of the lift force.
Based on Fig. 10.3, explain how the lift force is produced and how this force is able to cause the aircraft to take off.

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....

.... [3]

(c) Given that the area of the underside (bottom) of all wings of the aircraft is 25 m^2, determine the lift force produced when the aircraft is moving at 30 m/s.

lift force = ... [2]

(d) Given that the weight of the aircraft is 25 kN, estimate the speed of the aircraft necessary for it to take off from a runway.

speed = ... [2]

(e) Before platform doors were installed on all above-ground MRT stations in Singapore, all commuters waiting for trains at such MRT stations are told to stand behind the yellow line for their own safety (see Fig. 10.4)

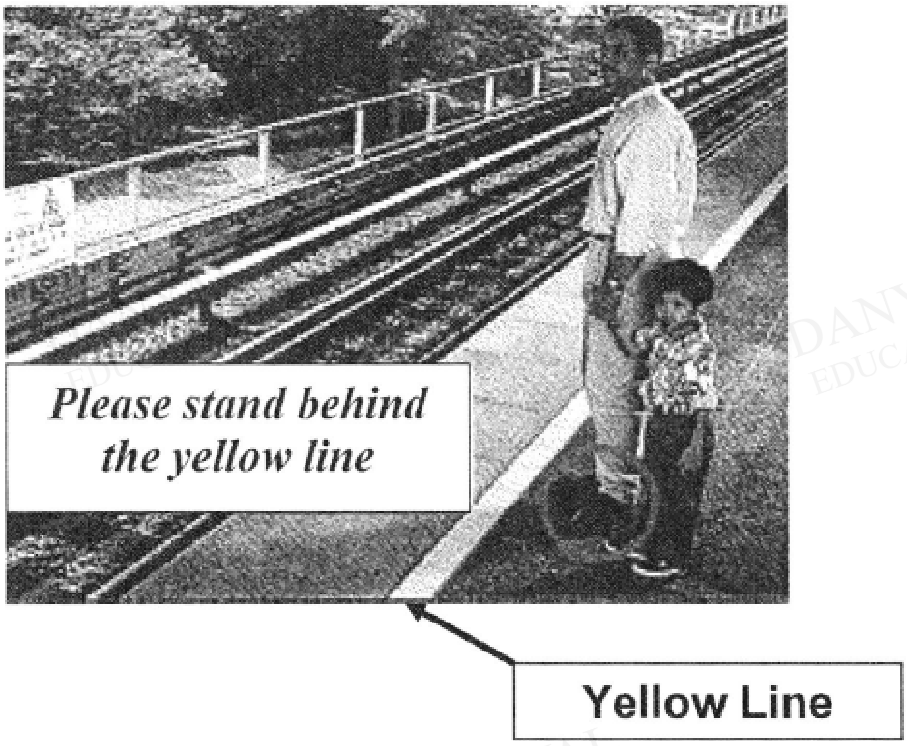

Fig. 10.4

(Reference: http://i.colnect.net/f/1467/907/Stand-behind-yellow-line.jpg)

By referring to your responses to the earlier parts of the question, explain why it is dangerous for commuters to stand on the yellow line, or too close to the rail tracks, when a train is entering the MRT station.

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....

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.... [2]

Answers

Pressure Test 1.0

Q1

ai	P=hρg = 15 x 1000 x 10 [M1] = 150 000 Pa [A1]
aii	Total P = 100 000 + 150 000 = 250 000 Pa or 2.5 x 10^5 Pa [A1]
b	Assume temperature remains the same when it is near the surface or at depth of 15 m. [B1] At depth of 15 m, pressure is higher than at the surface. the volume is smaller so the air molecules are moving a shorter distance before it impacts on the balloon walls or the **frequency of collisions is higher although its speed of impact and KE is the same.** [B1]
c	Air molecules are spaced further apart than water molecules [B1]

Q2

(a)(i)	**Pressure** = $\frac{force}{area}$ $F_{on\ load}$ = $F_{applied}$ x ($A_{applied}$ / $A_{on\ load}$) $F_{on\ load}$ = **4.0 x (0.15 x [30 / 10 000]** **= 200 N**	M1 A1
(ii)	It will move **upwards**. **Answers not accepted** • It move lesser / move more • Motion that direction is not stated	B1
(iii)	Air can be **compressed** and the **pressure** exerted at a piston will not be transmitted to the other piston. or Additional **work done** against compressing the air. **Wrong concept** Force exerted will not be accepted. The correct concept is the pressure is consistently transmitted through throughout a incompressible fluid.	A1
(b)(i)	76-70 = 6.0 cm Hg Pressure difference in Pa = 0.06 x 10 x 13600 = 8160Pa 8160 = 1.23 x 10 x h Height = 663.4 m = 663 m (3sf)	C1 C1 A1
(ii)	No. Atmospheric pressure is lower than at sea level and at lower atmospheric pressure boiling point will be lower. Alternatively, students can explain that latent heat is lesser as there is lesser atmospheric pressure acting on the surface of the liquid.	B1 B1

Q3

)a	Air molecules move freely and randomly at very high speeds. Water molecules move freely within liquid in random motion / sliding over one another.	B1 B1
)b	p = F / A $1.03 \times 10^5 = F / (2 \times 10^{-3})$ F = 206 N	 M1 A1
)c	When volume decreases, the number of air molecules per unit volume increases. The frequency of collision of air molecules with the walls increases, which increases the force of collision with the walls. *1 mark for every 2 correct sub-points This increases the force per unit area and the pressure.	B1 B1 B1
)d	pressure difference = density x gravitational field strength x height difference $(1.29 - 1.03) \times 10^5 = 1000 \times 10 \times h$ h = 2.6 m	 M1 A1
)e	The height difference depends on the pressure difference between the 2 water columns, (which does not depend on the cross sectional area of tubing).	B1

Q4

4a	10^5 N of force is exerted per unit area.	1
4b	P = hρg + 10^5 = 0.15 × 1000 × 10 + 10^5 = 102 000 Pa	 1 1
4c	• pressure at X is greater than Y • pressure at Y = P_{atm} • pressure at X = P_{atm} + water pressure due water to 2.0 cm of water	1 1 1
4d	When the water level is the tank is 13.0 cm from the base.	1

Q5

(a)	The faster the aircraft, the greater the pressure difference	[1]
(b)	• Air velocity above wings > air velocity below wings will cause air pressure above wings < air pressure below wings. • Upward net force acts on unit area of the wings. • Once upward net force > weight of aircraft, the aircraft takes off. (NOTE: students can repeat the point "the faster the aircraft, the greater the pressure difference" here, as part of their answer. But this point should not earn any credit in this part of the question – as it is a repetition of 10(a))	[1] [1] [1]
(c)	(At 30m/s), pressure difference = 794 – 551 = 243 Pa (Lift)force = pressure × area = 243 × 25 = 6075 N = **6080 N** (3 s.f.) or **6100 N** (2 s.f.)	[1] [1]
(d)	Pressure difference = F/A = 25000 / 25 = 1000 Pa From the table, minimum aircraft speed = **70 m/s**	[1] [1]
(e)	• (Due to approaching train) air between commuter and train will have high speed, resulting in lower pressure of air (between commuter and train). • Air behind commuter at relatively higher pressure than air between commuter and train. Net force acts on commuter, pushing him towards the train.	[1] [1]