7 **(a)** Two balls X and Y are supported by long strings, as shown in Fig. 7.1

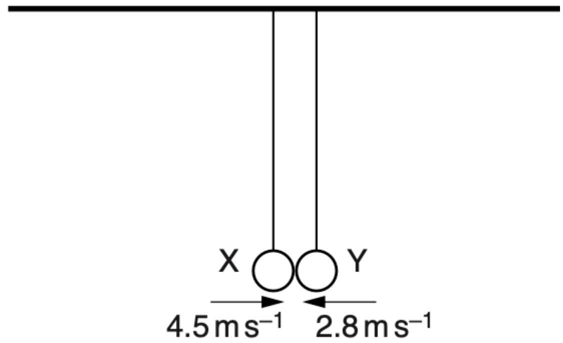

Fig. 7.1

The balls are each pulled back and released towards each other. When the balls collide at the position shown in Fig. 7.1, the strings are vertical, and the ball rebound in opposite directions.

Table 7.1 shows the mass and velocity data for X and Y before and after this collision.

Table 7.1

ball	mass / g	velocity just before collision / m s^{-1}	velocity just after collision / m s^{-1}
X	50	+4.5	–1.8
Y	*M*	–2.8	+1.4

(i) Determine the mass *M* of Y.

mass = ……………….... g [2]

(ii) State what is meant by an elastic collision.

…………………………………………………………………………………………………...……

………………………………………………………………………………………………………. [1]

(iii) Hence, or otherwise, by showing relevant calculations, determine if the collision in Fig. 7.1 is elastic or inelastic.

……

………………………………………………………………………………………………… [2]

(iv) A student said that it is possible for both balls to be concurrently stationary at some point in the collision.

State and explain if this is possible.

……

……

………………………………………………………………………………………………… [2]

(b) A block of mass 0.50 kg slides in a straight line with a constant speed of 0.25 m s^{-1} along a horizontal surface, as shown in Fig. 7.2.

Fig. 7.2

Assume that there are no resistive forces opposing the motion of the block.

The block hits a spring and decelerates. The speed of the block becomes zero when the compression of the spring is 8.0 cm.

The variation of the compression *x* of the spring with the force *F* applied to the spring is shown in Fig. 7.3.

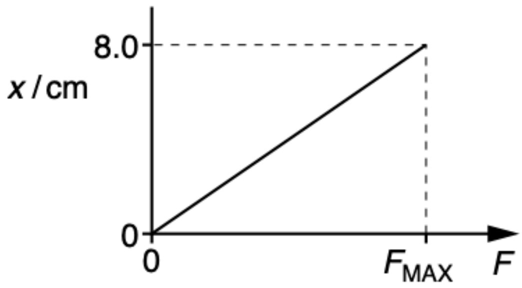

Fig. 7.3

(i) On Fig. 7.3, shade the area on the graph that represents the maximum elastic potential energy stored in the spring.

[1]

(ii) Hence, calculate the maximum force F_{MAX} applied on the spring.

maximum force F_{MAX} = ……………………. N [2]

(iii) The spring is replaced with another spring that is stiffer.

On Fig. 7.3, sketch the compression-force curve of the new spring.

[2]

(c) The Republic of Singapore Navy operates 4 Invincible class submarines, as seen in Fig. 7.4. The submarine displaces 2.2×10^6 kg of sea water when it is completely submerged. At neutral buoyancy, the weight of the submarine is equal to its upthrust. The submarine has 2 ballast tanks located at the front and back of the submarine respectively. Each ballast tank has a volume of 50 m^3, which can be partially or completely filled with sea water or air.

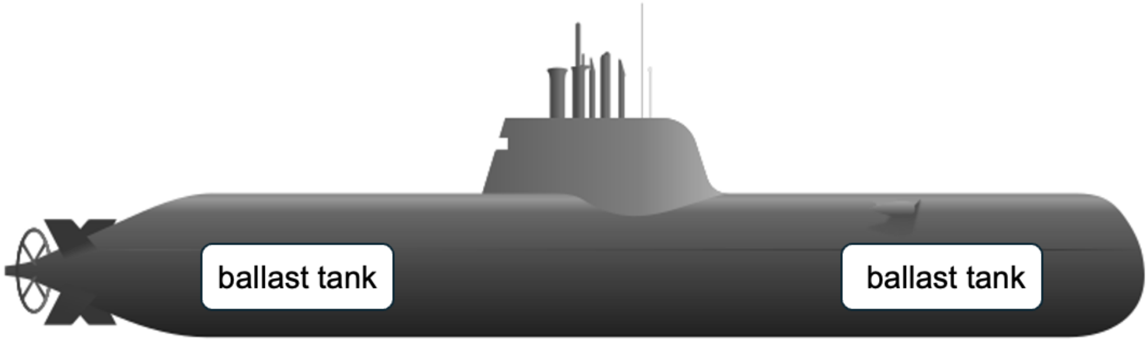

Fig 7.4

At neutral buoyancy, both ballast tanks are 25% filled with sea water. To descend, the submarine pumps air out of the 2 ballast tanks and fills them completely with sea water.

(i) Given that the density of sea water is 1030 kg m^{-3}, show that the increase in weight of the submarine when the ballast tanks are filled from 25% to 100% with sea water is 7.6×10^5 N.

[1]

(ii) Hence, calculate the maximum acceleration of the submarine.

maximum acceleration = ………………... m s^{-2} [2]

(iii)

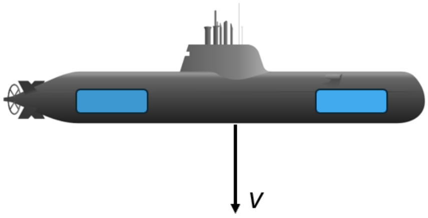

Fig. 7.5

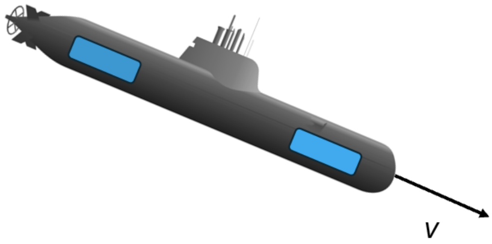

Fig. 7.6

In practice, the submarine does not descend vertically downwards (Fig. 7.5) but descends by moving forward at a downward angle (Fig 7.6).

Explain why this method allows the submarine to descend at a faster rate.

……………………………………………………………………………………………………..……

……………………………………………………………………………………………………..……

…………………………………………………………………………………………………….. [2]

(iv) Dive planes are installed on both side of the submarine. Each dive plane can be rotated about an axis such that its front edge points upwards or downwards. In Fig. 7.7, the submarine is travelling rightwards, and the dive plane is angled downwards. As a result, the water flowing past the dive plane is deflected upwards, and the submarine can assume the dive angle seen in Fig. 7.6.

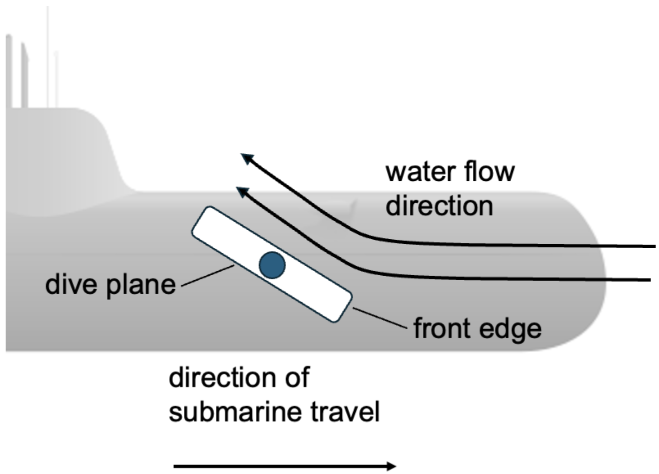

Fig. 7.7

By considering Newton's laws of motion, explain how the angled dive plane helps the submarine achieve the dive angle seen in Fig. 7.6.

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....

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.... [3]

[Total: 20]