RADLEY

2020 Scholarship Examination Paper

PHYSICS

26 February – 27 February 2020

Time allowed – 30 minutes

Calculators are not to be used

Total marks available = 33

Most of the marks in these questions are for showing how well you think. Your final answers are less important than demonstrating a logical and systematic approach.

You must show your working out at all stages and state any assumptions that you make.

Where you can, use powers of ten to show very big or very small numbers. For example “1,000,000” can be written: 1.0×10^6

1. A student is standing on the floor. They then jump vertically upwards into the air. In terms of the forces exerted by, and acting on the student, explain how they are able to leave the ground.

[4 marks]

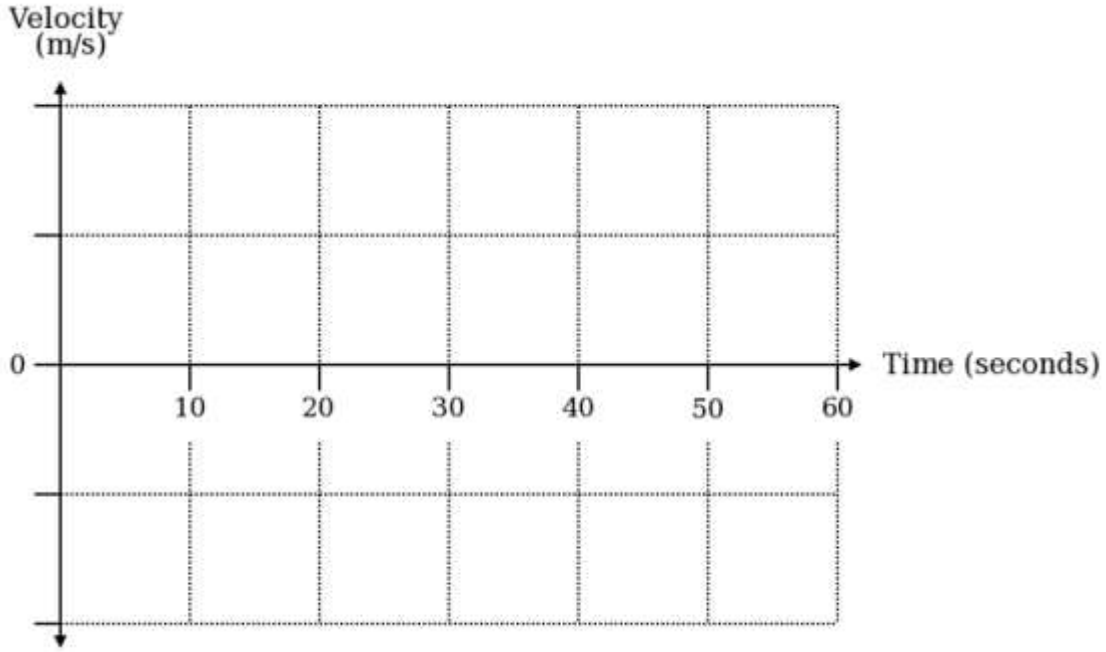
2. Relative velocity is the velocity of one object as observed from another object. For example, if car A is travelling at 10 mph and car B is travelling, in the same direction, at 15 mph then the velocity of car B relative to car A is 5mph. The driver of car A observes car B moving ahead at 5 mph.

Two cars are next to each other. They start from rest and travel along a straight road in the same direction. Their subsequent motion over the next 60 seconds is shown in the table below:

Car A	***Car B***
Acceleration = 2 m/s^2 for 10 seconds	Acceleration = 2 m/s^2 for 20 seconds
Acceleration = 0 m/s^2 for 40 seconds	Acceleration = 0 m/s^2 for 10 seconds
Acceleration = -1 m/s^2 for 10 seconds	Acceleration = -3 m/s^2 for 10 seconds
	Acceleration = 0 m/s^2 for 20 seconds

(a) Draw a velocity – time graph for the velocity of car B relative to car A (i.e. the velocity of car B as observed by the driver of car A). Add an appropriate scale to the velocity axis.

[4 marks]



(b) For the velocity - time graph drawn in part (a), what does the area under the graph represent?

[2 marks]

(c) Hence, using the graph that you have drawn or otherwise, calculate the separation of the cars after 60 seconds.

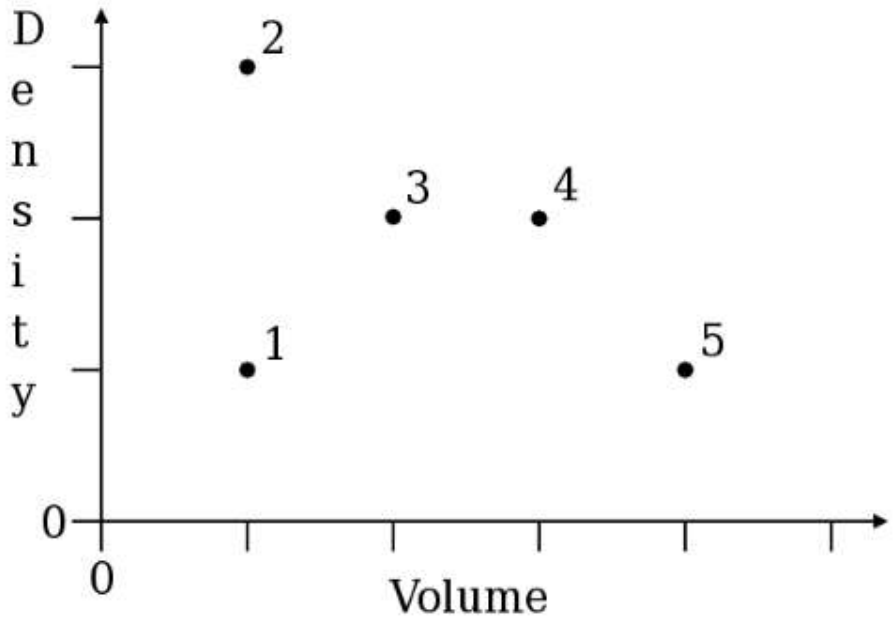
[4 marks]

3. **Estimate** the population density of the UK. Show your thinking clearly – it may help to draw a diagram.

NB The units for this quantity are people per square km.

[6 marks]

4. The density and volume of five samples of material are plotted on the graph as shown. Which two samples have the same mass? Explain your reasoning.



[3 marks]

5. An oil company has oilrigs in a part of the North Sea where there are icebergs in winter. To eliminate the danger of collision with the rigs, the company decided to try to melt the icebergs by coating them with soot.

(a) Explain why the company thought that coating the icebergs with soot might work.

[2 marks]

(b) Give THREE reasons why it might not work.

[3 marks]

6. Betelgeuse is a star in the constellation of Orion. Usually the tenth-brightest star in the night sky, at the moment it is unusually dim.

The mass of the Sun is sometimes given the symbol $M_\odot$ in astronomy. Betelguese has a mass of 12 $M_\odot$, and when it goes supernova (expected to occur within approximately the next 100,000 years) it will produce an explosion with a kinetic energy of 2×10^{44} J. However, it is very far from us (7×10^{18} m away) so although it will be bright enough to cast shadows at night, and be visible in the daytime, we needn't worry too much.



(a) If $M_\odot = 1.989 \times 10^{30}$ kg, and 90% of the mass of the star is blasted away in the supernova explosion, what is the mass of the very hot core left behind?

[2 marks]

(b) As you may know, the speed of light, $c = 3.0 \times 10^8$ m/s. If we were to observe Betelgeuse's supernova explosion occur tomorrow from the Earth, when would the supernova explosion actually have occurred?

[3 marks]