WESTMINSTER SCHOOL
THE CHALLENGE 2021

PHYSICS

Thursday 29 April 2021

Time allowed: 30 minutes

Please write in black or blue ink.
Calculators are allowed.
Write your answers in the spaces provided.

For examiner use only

Total Mark		

P1 (Multiple Choice – 10 marks)

Choose A,B,C,D or E for each of the following questions.

a) The mass of a short paperback book is about

A: 2g *B: 20g* *C: 200g* *D: 2kg* *E: 20kg*

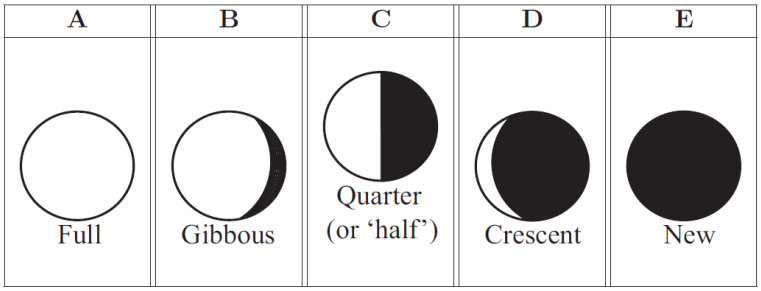
b) An Octopus swims through the water at 24 km/h. After 10 minutes it has travelled

A: 2000m *B: 4000m* *C: 6000m* *D: 24km* *E: 240km*

c) A device that turns electrical energy to sound energy is a

A: Generator B: Loudspeaker *C: Motor* *D: Turbine* *E: Microphone*

d) When the phase of the Moon as seen from the Earth is Full, what phase of the Earth is seen by an observer on the Moon?



e) An increase in pitch of a sound wave is equivalent to making which of these quantities **larger**?

A: Amplitude *B: Wavelength* *C: Frequency* *D: Period* *E: Speed*

f) Gravity is a force that can act over a distance without the objects exerting a force on each other being in contact. Another force that can do this is:

A: Friction B: Air resistance C: Upthrust D: Tension E: Magnetism

g) The 'light-year' is a unit of

A: Length B: Time C: Mass D: Area E: None of these

h) A large spring is compressed by a car. The spring has a length of 34 cm when the 500 kg car is empty, but it is compressed to 30 cm when the car has passengers with a total mass of 200 kg in it. What is the natural, uncompressed length of the spring?

A: 48 cm B: 46 cm C: 44 cm D: 42 cm E: 40 cm

i) An aeroplane is flying horizontally at constant speed. Which one of the following is **true** about the forces acting on it?

A: The lift upwards is greater than the weight downwards.

B: The forward thrust from the engines is slightly larger than the air resistance backwards.

C: The aeroplane has an overall force acting on it, in a forward direction.

D: The air resistance will decrease if the aeroplane speeds up.

E: None of the above statements are true

j) A person has a mass of 60 kg on the Earth. The moon's gravitational field is about 1/6 that of the Earth's. Which one of the following statements is **not true**?

A: The person will feel a stronger force of gravity on the Earth than the Moon.

B: The person's mass will be 60kg on the Moon.

C: The person's weight on the Moon is the same as his weight on the Earth.

D: An object dropped on the Earth will accelerate to the ground faster than on the Moon

E: A 1kg mass on the Earth will weigh more than a 1kg mass on the Moon.

Short answer Questions

P2 Ole Rømer was a Danish astronomer who, in 1676, made the first quantitative measurements of the speed of light.

He observed Jupiter's moons over the course of 8 years, and discovered that the exact times they went behind the planet (eclipsed) were approximately 20 minutes later when the Earth was farthest from Jupiter, compared with when the Earth was on the same side of the Sun as Jupiter (and therefore was closest.)

Hence he reckoned that light took 20 minutes to cross the* diameter *of the Earth's orbit around the Sun.

a) Given that the **radius** of the Earth's orbit is 1.5×10^{11}m, what value does this measurement imply for the speed of light in m/s?

[2]

b) The speed of light is now known to be 3.0×10^{8} m/s. By what percentage, rounded to 2 significant figures, does Rømer's value differ from this?

[2]

c) Much later, in 1905, Albert Einstein realised that the **speed of light was the same for all observers, regardless of their own speed**. This was the basis for his special theory of relativity. Theoretically, if you were travelling at 1.5×10^{8} m/s and turned on a torch, what speed would you measure its light moving away from you?

[1]

P3 The **barleycorn** is a unit of length equal to 0.847 cm, and still used as the basis of shoe sizes in English-speaking countries.

A **pennyweight** is a unit of mass equal to 1.56 grams. It is abbreviated **dwt**, *d* standing for *denarius* an ancient Roman coin, later used as the symbol of an old British penny.

a) A **rod** is another ancient unit, equal to 5.03m. Calculate the length of 1 rod in barleycorns.

[2]

b) The density of water is 1000 kg/m^3. Calculate its density in pennyweights per cubic barleycorn.

[2]

c) A cube of side 5 barleycorns has a mass of 100 pennyweights. If the gravitational field strength is 10 N/kg calculate the pressure in N/m^2 it exerts on the ground when resting on one of its faces.

[3]

P4

Draw the **magnetic field patterns** of the following. Draw each diagram carefully, and indicate the poles (N and S) on the magnets. Also, remember that field lines must have a direction.

a) 2 bar magnets with opposite poles adjacent.

[2]

b) 2 bar magnets with their south poles facing each other.

[2]

P5

You do *not* need any previous knowledge of capacitors to answer this question

A capacitor is an electrical device which stores charge. A textbook gives the following equation for working out the total capacitance of capacitors connected in series:

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + ...$$

where C = total capacitance, and C_1, C_2, C_3 etc are the values of the individual capacitors connected in series.

The unit of capacitance is the farad, with symbol F.

a) 3 capacitors are connected in series. Their values are 0.2 F, 0.3F and 0.6F. What is their total capacitance?

[2]

b) (i) What is the total capacitance of two 0.002F capacitors in series?

[2]

(ii) What is the total capacitance of two 50mF capacitors in series (1 mF = 0.001 F)?

[2]

b) From these answers, suggest an expression for the capacitance of two capacitors in series, each with identical capacitance X

[1]