Teacher Resource Bank

GCE Physics B: Physics in Context

Additional Sample Questions (Specification A)

PHYB4 – Physics Inside and Out

ADDITIONAL SAMPLE QUESTIONS

This document provides a directory of past questions from the legacy AQA GCE Physics Specification A; these questions may prove relevant/useful to both the teaching of the new AQA GCE Physics B: Physics in Context specification and the preparation of candidates for examined units. It is advisable when using these questions that teachers consider how these questions could relate to the new specification. Teachers should be aware of the different treatment of the Quality of Written Communication between the specifications.

For specific examples of the style and flavour of the questions which may appear in the operational exams, teachers should also refer to the Specimen Assessment Materials which accompany the specification.

A mark scheme has been produced which accompanies this document.

1. The gravitational field strength at the surface of a planet, X, is 19 N kg^{-1}.

(a) (i) Calculate the gravitational potential difference between the surface of X and a point 10 m above the surface, if the gravitational field can be considered to be uniform over such a small distance.

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(ii) Calculate the minimum amount of energy required to lift a 9.0 kg rock a vertical distance of 10m from the surface of X.

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(iii) State whether the minimum amount of energy you have found in part (a)(ii) would be different if the 9.0 kg mass were lifted a vertical distance of 10 m from a point near the top of the highest mountain of planet X. Explain your answer.

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(3)

(b) Calculate the gravitational field strength at the surface of another planet, Y, that has the same mass as planet X, but twice the diameter of X.

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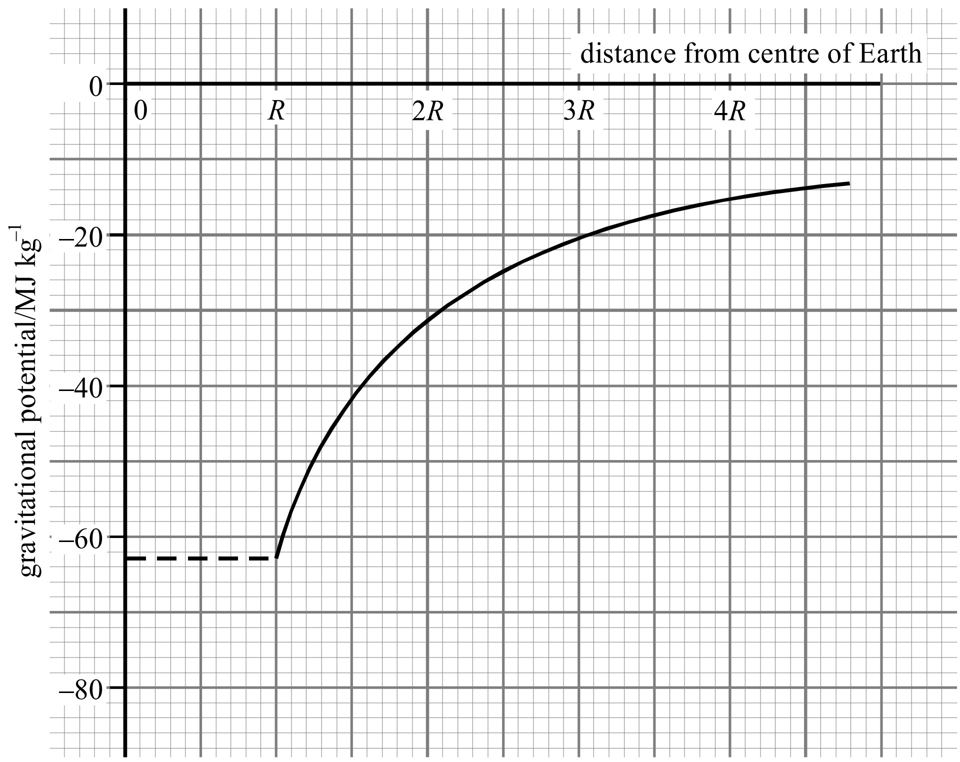
(2)
(Total 5 marks)

2. (a) The graph shows how the gravitational potential varies with distance in the region above the surface of the Earth. R is the radius of the Earth, which is 6400 km. At the surface of the Earth, the gravitational potential is –62.5 MJ kg^{-1}



Use the graph to calculate

(i) the gravitational potential at a distance $2R$ from the centre of the Earth,

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(ii) the increase in the potential energy of a 1200kg satellite when it is raised from the surface of the Earth into a circular orbit of radius $3R$.

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(4)

(b) (i) Write down an equation which relates gravitational field strength and gravitational potential.

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(ii) **By use of the graph** in part (a), calculate the gravitational field strength at a distance $2R$ from the centre of the Earth.

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(iii) Show that your result for part (b)(ii) is consistent with the fact that the surface gravitational field strength is about 10 N kg^{-1}.

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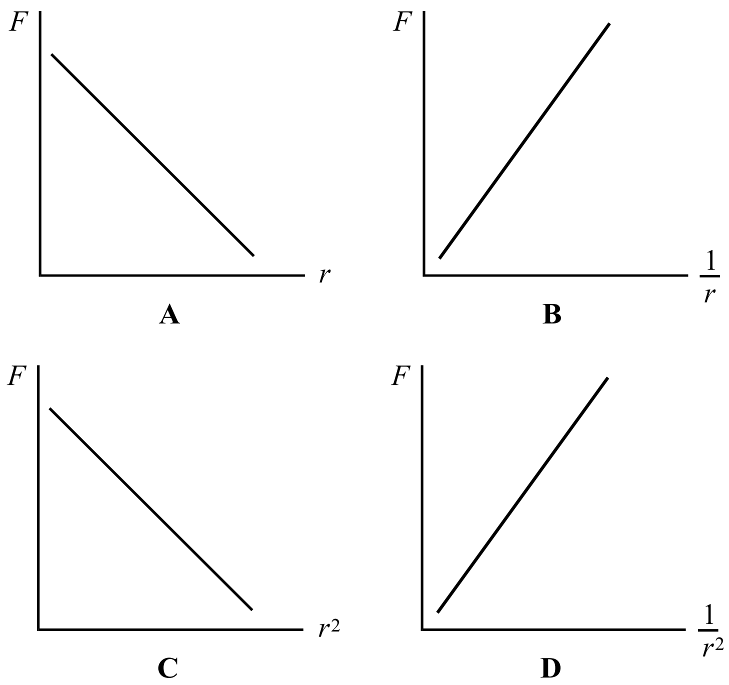
(5)
(Total 9 marks)

3. Which one of the following graphs correctly shows the relationship between the gravitational force, *F*, between two masses and the distance, *r*, between them?



(Total 1mark)

4. A satellite is in orbit at a height h above the surface of a planet of mass M and radius R. What is the velocity of the satellite?

A $\sqrt{\dfrac{GM(R+h)}{R}}$

B $\dfrac{\sqrt{GM(R+h)}}{R}$

C $\sqrt{\dfrac{GM}{(R+h)}}$

D $\dfrac{\sqrt{GM}}{(R+h)}$

(Total 1 mark)

5. A planet of mass M and radius R rotates so rapidly that loose material at the equator just remains on the surface. What is the period of rotation of the planet?

G is the universal gravitational constant.

A $2\pi\sqrt{\dfrac{R}{GM}}$

B $2\pi\sqrt{\dfrac{R^2}{GM}}$

C $2\pi\sqrt{\dfrac{GM}{R^3}}$

D $2\pi\sqrt{\dfrac{R^3}{GM}}$

(Total 1 mark)

6. Communications satellites are usually placed in a *geo-synchronous orbit*.

(a) State **two** features of a geo-synchronous orbit.

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(2)

(b) Given that the mass of the Earth is 6.00×10^{24} kg and its mean radius is 6.40×10^{7} m,

(i) show that the radius of a geo-synchronous orbit must be 4.23×10^{7} m,

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(ii) calculate the increase in potential energy of a satellite of mass 750 kg when it is raised from the Earth's surface into a geo-synchronous orbit.

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(6)
(Total 8 marks)

7. A planet has a radius half of the Earth's radius and a mass a quarter of the Earth's mass. What is the approximate gravitational field strength on the surface of the planet?

A 1.6 N kg^{-1}
B 5.0 N kg^{-1}
C 10 N kg^{-1}
D 20 N kg^{-1}

(Total 1 mark)

8. What is the angular speed of a point on the Earth's equator?

A 7.3×10^{-5} rad s^{-1}

B 4.2×10^{-3} rad s^{-1}

C 2.6×10^{-1} rad s^{-1}

D 15 rad s^{-1}

(Total 1 mark)

9. The following data refer to two planets.

	radius/km	density/kg m^{-3}
planet P	8 000	6 000
planet Q	16 000	3 000

The gravitational field strength at the surface of P is 13.4 N kg^{-1}. What is the gravitational field strength at the surface of Q?

A 3.4 N kg^{-1}

B 13.4 N kg^{-1}

C 53.6 N kg^{-1}

D 80.4 N kg^{-1}

(Total 1 mark)

10. (a) The Moon's orbit around the Earth may be assumed to be circular. Explain why no work is done by the gravitational force that acts on the Moon to keep it in orbit around the Earth.

You may be awarded marks for the quality of written communication provided in your answer.

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(3)

(b) Give an example of a situation where a body

(i) travels at constant speed but experiences a continuous acceleration,

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(ii) experiences a maximum acceleration when its speed is zero.

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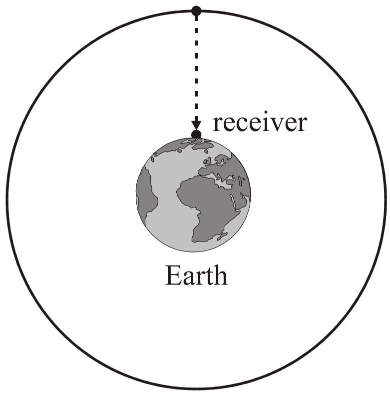
(2)
(Total 5 marks)

11. The Global Positioning System (GPS) is a system of satellites that transmit radio signals which can be used to locate the position of a receiver anywhere on Earth.



(a) A receiver at sea level detects a signal from a satellite in a circular orbit when it is passing directly overhead as shown in the diagram above.

(i) The microwave signal is received 68 ms after it was transmitted from the satellite. Calculate the height of the satellite.

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(ii) Show that the gravitational field strength of the Earth at the position of the satellite is 0.56 N kg^{-1}.

mass of the Earth = 6.0×10^{24} kg
mean radius of the Earth = 6400 km

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(4)

(b) For the satellite in this orbit, calculate

(i) its speed,

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(ii) its time period.

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(5)
(Total 9 marks)

12. A dish on a communications satellite is used to transmit a beam of microwaves of wavelength λ. The beam spreads with an angular width λ/d, in radians, where d is the diameter of the dish.

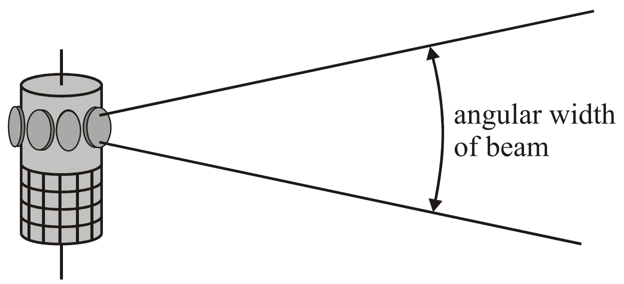

Figure 1

(a) (i) Calculate the angular width, in degrees, of a beam of frequency 1200 MHz transmitted using a dish of diameter 1.8 m.

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(ii) Show that the beam has a width of 2100 km at a distance of 15 000 km from the satellite.

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(4)

(b) (i) Show that the speed, *v*, of a satellite in a circular orbit at height *h* above the Earth is given by

$$v\sqrt{\frac{GM}{(R+h)}}$$

where *R* is the radius of the Earth and *M* is the mass of the Earth.

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(ii) Calculate the speed and the time period of a satellite at a height of 15 000 km in a circular orbit about the Earth.

mass of the Earth = 6.00×10^{24} kg
radius of the Earth = 6.40×10^{6} m

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(iii) The satellite passes directly over a stationary receiver at the North Pole. Show that the beam moves at a speed of 1.3 km s^{-1} across the Earth's surface and that the receiver can remain in contact with the satellite for no more than 27 minutes each orbit.

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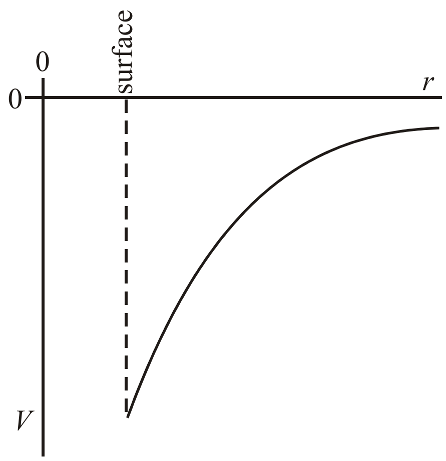
(9)
(Total 13 marks)

13. The graph shows how the gravitational potential, V , varies with the distance, r , from the centre of the Earth.



What does the gradient of the graph at any point represent?

A the magnitude of the gravitational field strength at that point
B the magnitude of the gravitational constant
C the mass of the Earth
D the potential energy at the point where the gradient is measured

(Total 1 mark)

14. (a) State, in words, Newton's law of gravitation.

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(3)

(b) By considering the centripetal force which acts on a planet in a circular orbit, show that $T^2 \propto R^3$, where T is the time taken for one orbit around the Sun and R is the radius of the orbit.

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(3)

(c) The Earth's orbit is of mean radius 1.50×10^{11} m and the Earth's year is 365 days long.

(i) The mean radius of the orbit of Mercury is 5.79×10^{10} m. Calculate the length of Mercury's year.

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(ii) Neptune orbits the Sun once every 165 Earth years.

Calculate the ratio $\dfrac{\text{distance from Sun to Neptune}}{\text{distance from Sun to Earth}}$.

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(4)
(Total 10 marks)

15. (a) Artificial satellites are used to monitor weather conditions on Earth, for surveillance and for communications. Such satellites may be placed in a *geo-synchronous* orbit or in a low polar orbit.

Describe the properties of the geo-synchronous orbit and the advantages it offers when a satellite is used for communications.

You may be awarded marks for the quality of written communication in your answer.

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(3)

(b) A satellite of mass m travels at angular speed ω in a circular orbit at a height h above the surface of a planet of mass M and radius R.

(i) Using these symbols, give an equation that relates the gravitational force on the satellite to the centripetal force.

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(ii) Use your equation from part (b)(i) to show that the orbital period, T, of the satellite is given by

$$T^2 = \frac{4\pi^2 (R+h)^3}{GM}$$

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(iii) Explain why the period of a satellite in orbit around the Earth cannot be less than 85 minutes. Your answer should include a calculation to justify this value.

mass of the Earth = 6.00×10^{24} kg
kg radius of the Earth = 6.40×10^{6} m

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(6)

(c) Describe and explain what happens to the speed of a satellite when it moves to an orbit that is closer to the Earth.

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(2)
(Total 11 marks)

16. When at the surface of the Earth, a satellite has weight *W* and gravitational potential energy –*U*. It is projected into a circular orbit whose radius is equal to twice the radius of the Earth. Which line, **A** to **D**, in the table shows correctly what happens to the weight of the satellite and to its gravitational potential energy?

	weight	**gravitational potential energy**
A	becomes $\frac{W}{2}$	increases by $\frac{U}{2}$
B	becomes $\frac{W}{4}$	increases by $\frac{U}{2}$
C	remains *W*	increases by *U*
D	becomes $\frac{W}{4}$	increases by *U*

(Total 1 mark)

17. Which one of the following statements is **not** true for a body vibrating in simple harmonic motion when damping is present?

A The damping force is always in the opposite direction to the velocity.

B The damping force is always in the opposite direction to the acceleration.

C The presence of damping gradually reduces the maximum potential energy of the system.

D The presence of damping gradually reduces the maximum kinetic energy of the system.

(Total 1 mark)

18. (a) State what is meant by

(i) a free vibration,

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(ii) a forced vibration.

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(2)

(b) A car and its suspension can be treated as a simple mass-spring system. When four people of total weight 3000 N get into a car of weight 6000 N, the springs of the car are compressed by an extra 50 mm.

(i) Calculate the spring constant, k, of the system.

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(ii) Show that, when the system is displaced vertically and released, the time period of the oscillations is 0.78 s.

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(3)

(c) The loaded car in part (b) travels at 20 ms^{-1} along a road with humps spaced 16 m apart.

(i) Calculate the time of travel between the humps.

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(ii) Hence, state and explain the effect the road will have on the oscillation of the car.

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(3)
(Total 8 marks)

19. A spring, which obeys Hooke's law, hangs vertically from a fixed support and requires a force of 2.0 N to produce an extension of 50mm. A mass of 0.50kg is attached to the lower end of the spring. The mass is pulled down a distance of 20mm from the equilibrium position and then released.

(a) (i) Show that the time period of the simple harmonic vibrations is 0.70s.

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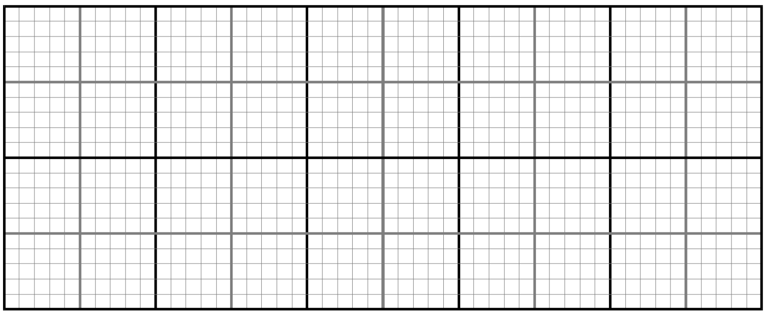
(ii) Sketch the displacement of the mass against time, starting from the moment of release and continuing for two oscillations. Show appropriate time and distance scales on the axes.



(5)

(b) The mass-spring system described in part (a) is attached to a support which can be made to vibrate vertically with a small amplitude. Describe the motion of the mass-spring system with reference to frequency and amplitude when the support is driven at a frequency of

(i) 0.5 Hz**,**

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(ii) 1.4 Hz.

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(3)
(Total 8 marks)

20. A body is in simple harmonic motion of amplitude 0.50 m and period 4π seconds. What is the speed of the body when the displacement of the body is 0.30 m?

A $0.10 ms^{-1}$

B $0.15 ms^{-1}$

C $0.20 m s^{-1}$

D $0.40 m s^{-1}$

(Total 1 mark)

21. A particle oscillates with undamped simple harmonic motion. Which one of the following statements about the acceleration of the oscillating particle is true?

A It is least when the speed is greatest.

B It is always in the opposite direction to its velocity.

C It is proportional to the frequency.

D It decreases as the potential energy increases.

(Total 1mark)

22. A particle of mass 5.0×10^{-3} kg performing simple harmonic motion of amplitude 150 mm takes 47 s to make 50 oscillations. What is the maximum kinetic energy of the particle?

A 2.0×10^{-3} J
B 2.5×10^{-3} J
C 3.9×10^{-3} J
D 5.0×10^{-3} J

(Total 1mark)

23. (a) A body is moving with simple harmonic motion. State **two** conditions that must be satisfied concerning the *acceleration* of the body.

condition 1

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condition 2

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(2)

(b) A mass is suspended from a vertical spring and the system is allowed to come to rest.
When the mass is now pulled down a distance of 76 mm and released, the time taken for 25 oscillations is 23 s.

Calculate

(i) the frequency of the oscillations,

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(ii) the maximum acceleration of the mass,

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(iii) the displacement of the mass from its rest position 0.60 s after being released.
State the direction of this displacement.

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(6)

(c)

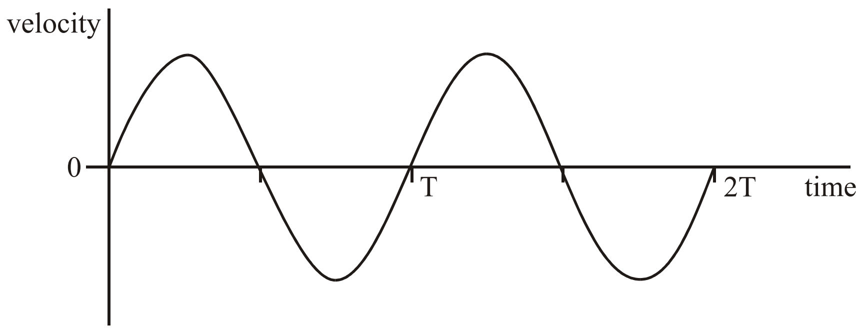

Figure 1

Figure 1 shows qualitatively how the velocity of the mass varies with time over the first two cycles after release.

(i) Using the axes in **Figure 2**, sketch a graph to show qualitatively how the displacement of the mass varies with time during the same time interval.

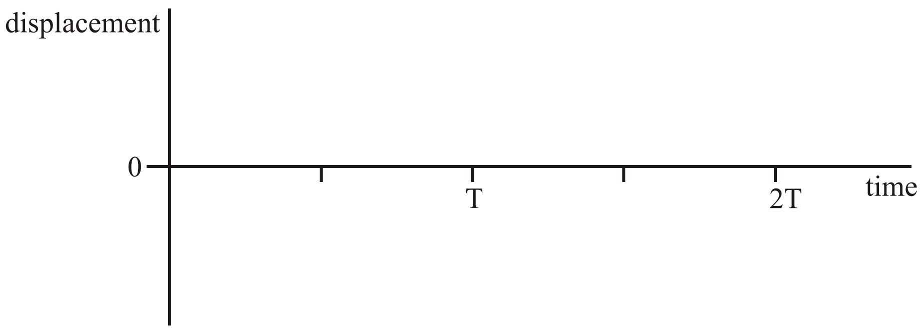

Figure 2

(ii) Using the axes in **Figure 3**, sketch a graph to show qualitatively how the potential energy of the mass-spring system varies with time during the same time interval.

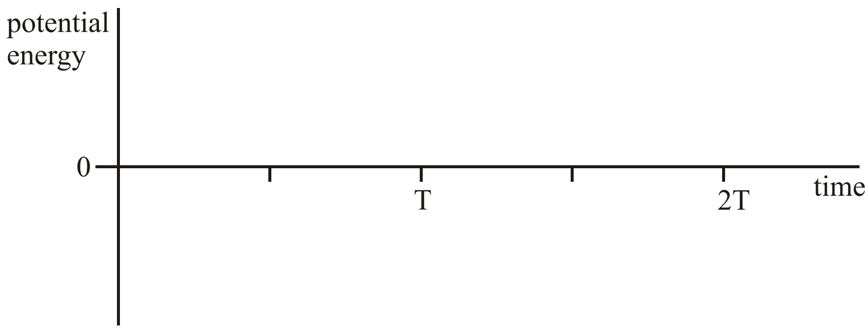

Figure 3

(4)
(Total 12 marks)

24. (a) A spring, which hangs from a fixed support, extends by 40 mm when a mass of 0.25 kg is suspended from it.

(i) Calculate the spring constant of the spring.

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(ii) An additional mass of 0.44 kg is then placed on the spring and the system is set into vertical oscillation. Show that the oscillation frequency is 1.5 Hz.

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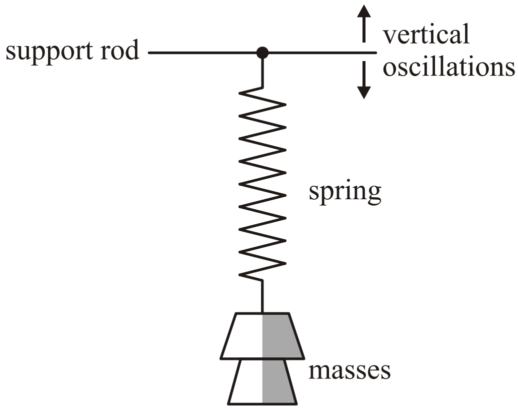
(4)

(b) With both masses still in place, the spring is now suspended from a horizontal support rod that can be made to oscillate vertically, as shown in the figure below, with amplitude 30 mm at several different frequencies.



Describe fully, with reference to amplitude, frequency and phase, the motion of the masses suspended from the spring in each of the following cases.

(i) The support rod oscillates at a frequency of 0.2 Hz.

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(ii) The support rod oscillates at a frequency of 1.5 Hz.

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(iii) The support rod oscillates at a frequency of 10 Hz.

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(6)
(Total 10 marks)

25. A particle of mass m oscillates with amplitude A at frequency f. What is the maximum kinetic energy of the particle?

A $\frac{1}{2}\pi^2 mf^2A^2$

B $\pi^2 mf^2A^2$

C $2\pi^2 mf^2A^2$

D $4\pi^2 mf^2A^2$

(Total 1mark)

26. An early form of four-stroke gas engine stores kinetic energy in a large flywheel driven by the crankshaft. The engine is started from rest with its load disconnected and produces a torque which accelerates the flywheel to it's off-load running speed of 90 rev $min^{-1.}$

(a) The flywheel has a moment of inertia of 250 kg m^2 and takes 8.0 s to accelerate from rest to 90 rev min^{-1}.

(i) Show that the angular acceleration of the flywheel is 1.2 rad $s^{-2.}$

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(ii) Calculate the average accelerating torque acting on the flywheel.

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(iii) Calculate the rotational kinetic energy stored in the flywheel at the end of its acceleration.

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(iv) Calculate the average useful power output of the engine during this accelerating period.

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(5)

(b) When the engine is running steadily at 90 rev min^{-1} off-load, the gas supply is suddenly shut off and the flywheel continues to rotate for a further 32 complete turns before coming to rest.

(i) Estimate the average retarding torque acting on the flywheel.

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(ii) Assuming that the average retarding torque on the flywheel is the same when the engine is running, estimate the average power which the engine must develop when running to keep the flywheel turning at 90 rev min^{-1} off-load.

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(5)
(Total 10 marks)

27. A potter in an African village makes large clay pots on a stone wheel. The wheel rotates freely on a central bearing and is driven by the potter, who applies a tangential force repeatedly to its rim using his foot until the wheel reaches its normal working angular speed. He then stops driving and throws a lump of clay onto the centre of the wheel.

(a) The normal working angular speed of the wheel is 5.0 rad s^{-1}. The moments of inertia of the wheel and the clay about the axis of rotation are 1.6 kg m^2 and 0.25 kg m^2, respectively. When the clay is added, the angular speed of the wheel changes suddenly. The net angular impulse is zero.

Calculate the angular speed of the wheel immediately after the clay has been added.

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(2)

(b) The potter now applies a tangential force to the rim of the wheel during one quarter of its revolution so that the angular speed returns to 5.0 rad s^{-1}. The wheel has a diameter of 0.62 m.

Calculate

(i) the angular acceleration of the wheel,

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(ii) the average tangential force which must be applied by the potter.

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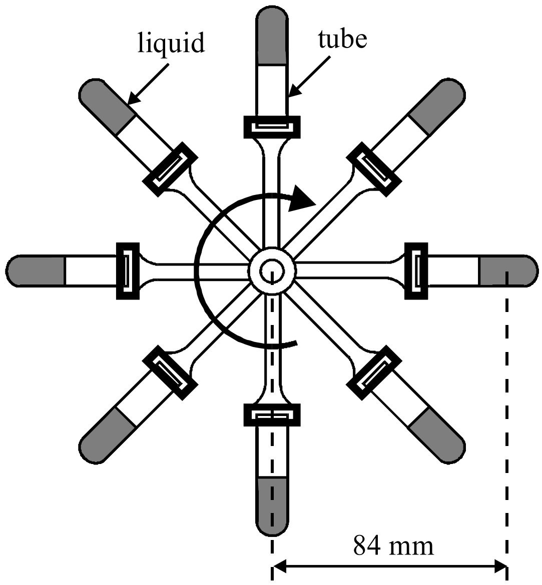
(4)
(Total 6 marks)

28. The diagram shows an overhead view of the load carrier of a spinning centrifuge, used to separate solid particles from the liquid in which they are suspended.



(a) When the centrifuge is operated with empty tubes, it reaches its working angular speed of 1100 rad s^{-1} in a time of 4.2 s, starting from rest. The moment of inertia of this system is 7.6×10^{-4} kg m^2. Calculate

(i) the angular acceleration of the system,

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(ii) the torque required to produce this angular acceleration.

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(2)

(b) In normal operation, each of the eight tubes contains 3.0×10^{-3} kg of liquid, whose centre of mass, when spinning, is 84 mm from the axis of rotation. The torque produced by the motor is the same as when the tubes are empty.

Show that this system takes approximately 5 s to reach its working speed of 1100 rad s^{-1}, starting from rest.

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(3)

(c) The normal operating cycle of the centrifuge takes a total time of 1 min. The centrifuge accelerates uniformly during the first 5.0 s to a speed of 1100 rad s^{-1}, after which the speed remains constant until the final 6.0 s of the cycle, during which it is brought to rest uniformly.
Calculate the angle turned by a tube during one complete operating cycle.

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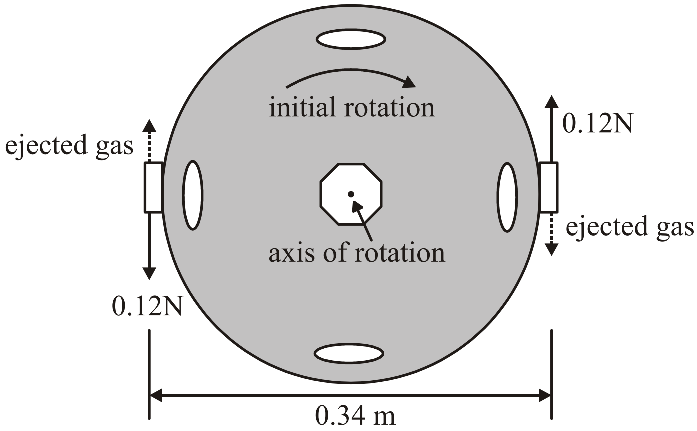
(3)
(Total 8 marks)

29. The figure below shows a remote-control camera used in space for inspecting space stations. The camera can be moved into position and rotated by firing ‘thrusters’ which eject xenon gas at high speed. The camera is spherical with a diameter of 0.34 m.

In use, the camera develops a spin about its axis of rotation. In order to bring it to rest, the thrusters on opposite ends of a diameter are fired, as shown in the figure below.



(a) When fired, each thruster provides a constant force of 0.12 N.

(i) Calculate the torque on the camera provided by the thrusters.

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(ii) The moment of inertia of the camera about its axis of rotation is 0.17 kg m^2. Show that the angular deceleration of the camera whilst the thrusters are firing is 0.24 rad s^{-2}.

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(3)

(b) The initial rotational speed of the camera is 0.92 rad s^{-1}. Calculate

(i) the time for which the thrusters have to be fired to bring the camera to rest,

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(ii) the angle turned through by the camera whilst the thrusters are firing. Express your answer in degrees.

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(3)
(Total 6 marks)

30. A girl of mass 40 kg stands on a roundabout 2.0 m from the vertical axis as the roundabout rotates uniformly with a period of 3.0 s. The horizontal force acting on the girl is approximately

A zero.

B 3.5×10^2 N.

C 7.2×10^2 N.

D 2.8×10^4 N.

(Total 1mark)

31. For a particle moving in a circle with uniform speed, which one of the following statements is **incorrect**?

A The velocity of the particle is constant.

B The force on the particle is always perpendicular to the velocity of the particle.

C There is no displacement of the particle in the direction of the force.

D The kinetic energy of the particle is constant.

(Total 1mark)

32. A fairground roundabout makes nine revolutions in one minute. What is the angular speed of the roundabout?

A 0.15 rad s^{-1}
B 0.34 rad s^{-1}
C 0.94 rad s^{-1}
D 2.1 rad s^{-1}

(Total 1mark)

33. A particle of mass *m* moves in a circle of radius *r* at uniform speed, taking time *T* for each revolution. What is the kinetic energy of the particle?

A $\dfrac{\pi^2 m r}{T^2}$

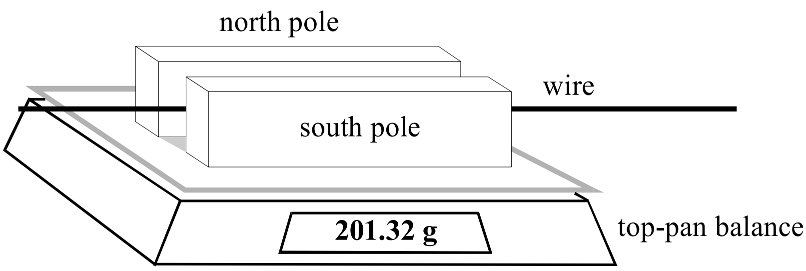
B $\dfrac{\pi^2 m r^2}{T^2}$

C $\dfrac{2\pi^2 m r^2}{T}$

D $\dfrac{2\pi^2 m r^2}{T^2}$

(Total 1mark)

34. The diagram shows a magnet placed on a top-pan balance. A fixed horizontal wire, through which a current can flow, passes centrally through the magnetic field parallel to the pole-pieces.
With no current flowing, the balance records a mass of 201.32g. When a current of 5.0A flows, the reading on the balance is 202.86 g.



(a) (i) Explain why the reading on the balance increased when the current was switched on.

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(ii) State the direction of current flow and explain your answer.

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(iii) If the length of the wire in the magnetic field is 60 mm, estimate the flux density of the magnetic field.

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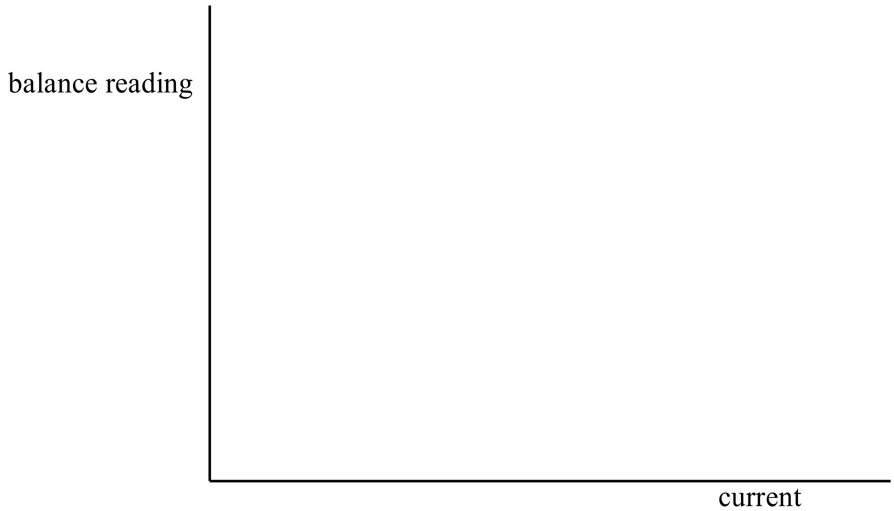
(6

(b) Sketch a graph to show how you would expect the balance reading to change if the current through the wire was changed.



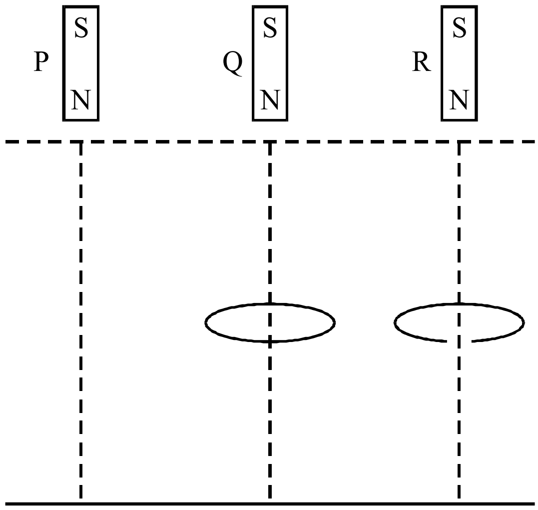
(2)
(Total 8 marks)

35. Which line, **A** to **D**, gives correct units for both magnetic flux and magnetic flux density?

	magnetic flux	magnetic flux destiny
A	Wb m^{-2}	Wb
B	Wb	T
C	Wb m^{-2}	T m^{-2}
D	T m^{-2}	Wb m^{-2}

(Total 1mark)

36.



Three identical magnets P, Q and R are released simultaneously from rest and fall to the ground from the same height. P falls directly to the ground, Q falls through the centre of a thick conducting ring and R falls through a ring which is identical except for a gap cut into it. Which one of the statements below correctly describes the sequence in which the magnets reach the ground?

A P and R arrive together followed by Q.

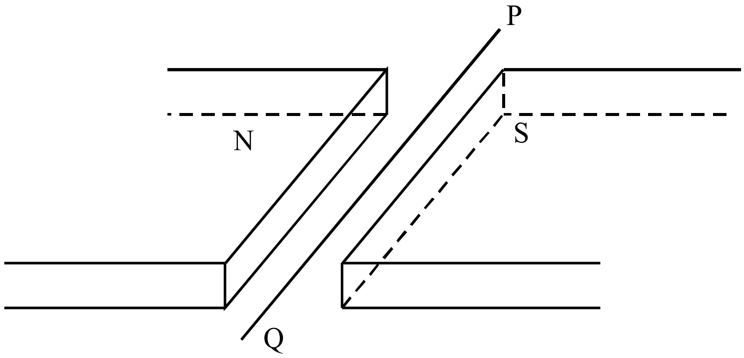
B P and Q arrive together followed by R.

C P arrives first, followed by Q which is followed by R.

D All three magnets arrive simultaneously.

(Total 1mark)

37.



A wire lies perpendicularly across a horizontal uniform magnetic field of flux density 20×10^{-3} T so that 0.30 m of the wire is effectively subjected to the field. If the force exerted on this length of wire due to a current in it is 30×10^{-3} N downward, what is the current in the wire?

A 0.45 A from P to Q

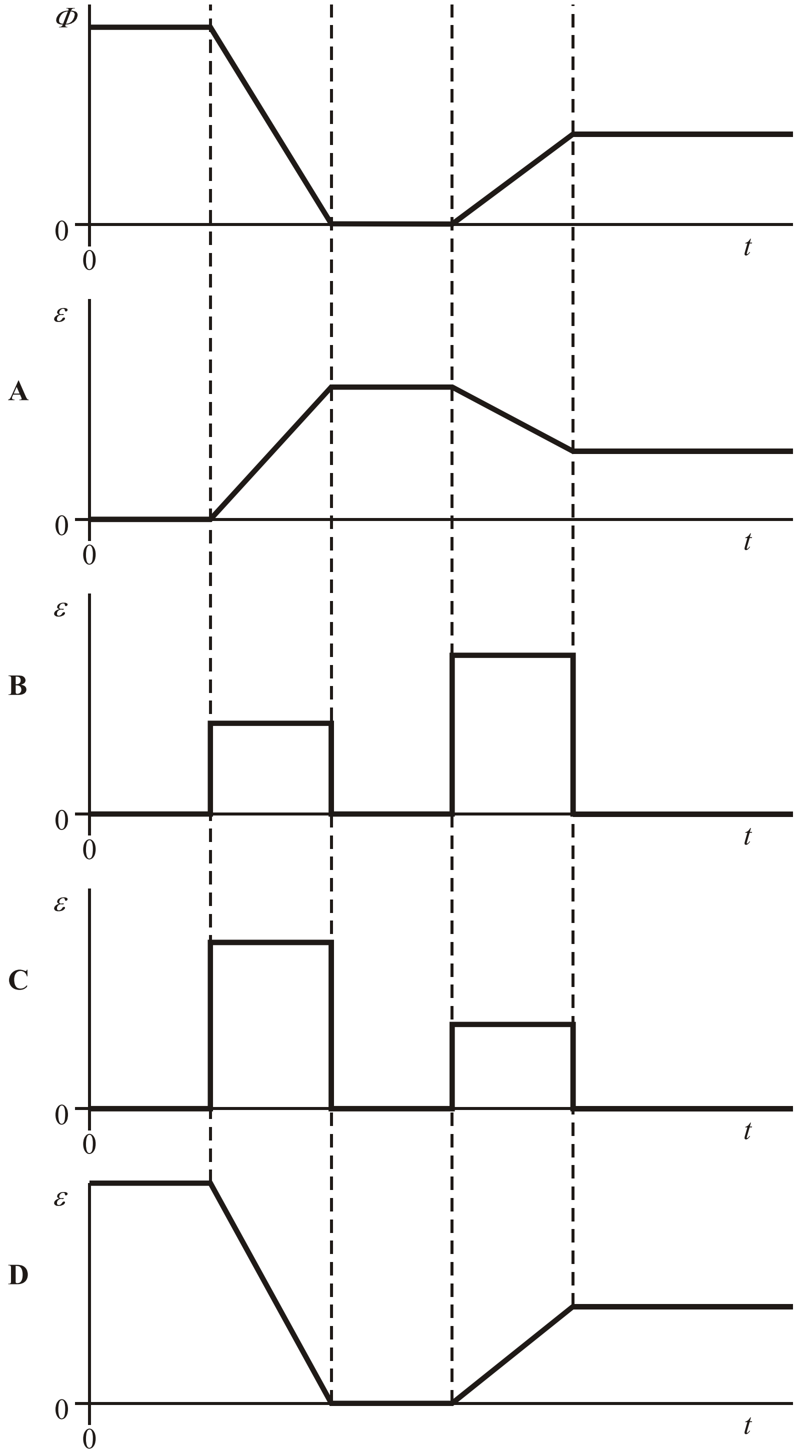
B 0.45 A from Q to P

C 5.0 A from P to Q

D 5.0 A from Q to P

(Total 1mark)

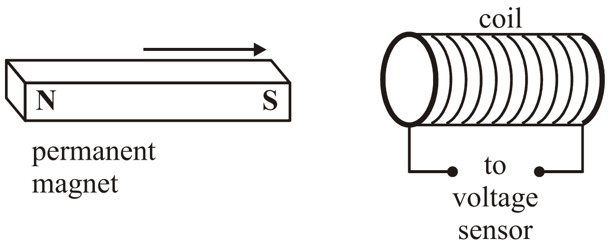
38. The magnetic flux, Φ, through a coil varies with time, t, as shown by the first graph. Which one of the following graphs, **A** to **D**, best represents how the magnitude, ε, of the induced emf varies in this same period of time?



(Total 1mark)

39. (a) In an experiment to illustrate electromagnetic induction, a permanent magnet is moved towards a coil, as shown in **Figure 1**, causing an emf to be induced across the coil.

Figure 1



Using Faraday's law, explain why a larger emf would be induced in this experiment if a stronger magnet were moved at the same speed.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

....

....

....

....

....

(3)

(b) A conductor of length l is moved at a constant speed v so that it passes perpendicularly through a uniform magnetic field of flux density B, as shown in **Figure 2**.

Figure 2

(i) Give an expression for the area of the magnetic field swept out by the conductor in time Δt.

....

....

(ii) Show that the induced emf, ∈ , across the ends of the conductor is given by

$$\in = Blv.$$

....

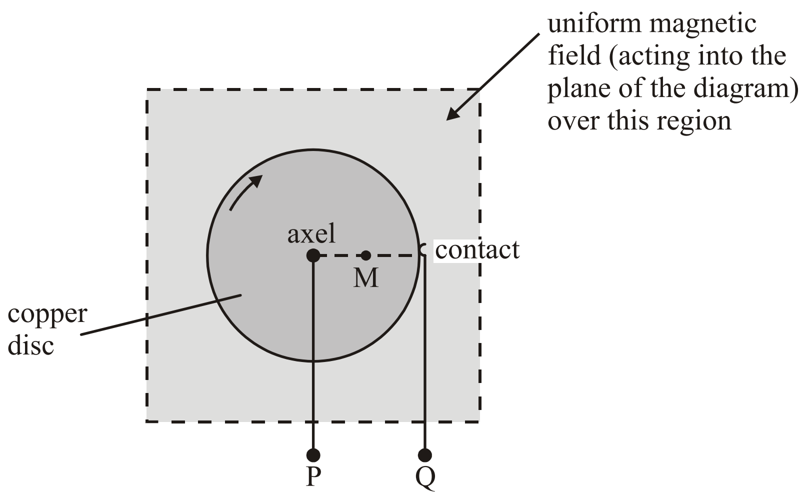
....

....

(3)

(c) A simple electrical generator can be made from a copper disc, which is rotated at right angles to a uniform magnetic field, directed into the plane of the diagram (**Figure 3**). An emf is developed across terminals P (connected to the axle) and Q (connected to a contact on the edge of the disc).

Figure 3



The radius of the disc is 64 mm and it is rotated at 16 revolutions per second in a uniform magnetic field of flux density 28 mT.

(i) Calculate the angular speed of the disc.

....

....

....

(ii) Calculate the linear speed of the mid-point M of a radius of the disc.

....

....

....

(iii) Hence, or otherwise, calculate the emf induced across terminals P and Q.

....

....

....

(5)
(Total 11 marks)

40. Bundles of optical fibres are described as either *coherent* or *non-coherent.*

(a) Describe how the fibres are arranged in each type of bundle and explain how the different designs determine their optical characteristics.

....

....

....

....

....

....

....

(2)

(b) State an application for each type of bundle.

application of *coherent* bundle ....

....

application of *non-coherent* bundle ....

....

(2)

(c) (i) Give **two** advantages of a bundle consisting of fibres of very small diameter over a bundle consisting of larger fibres.

advantage 1 ....

....

advantage 2 ....

....

(ii) Give **two** reasons why a glass cladding is used around the central core of each fibre in a coherent bundle.

reason 1 ....

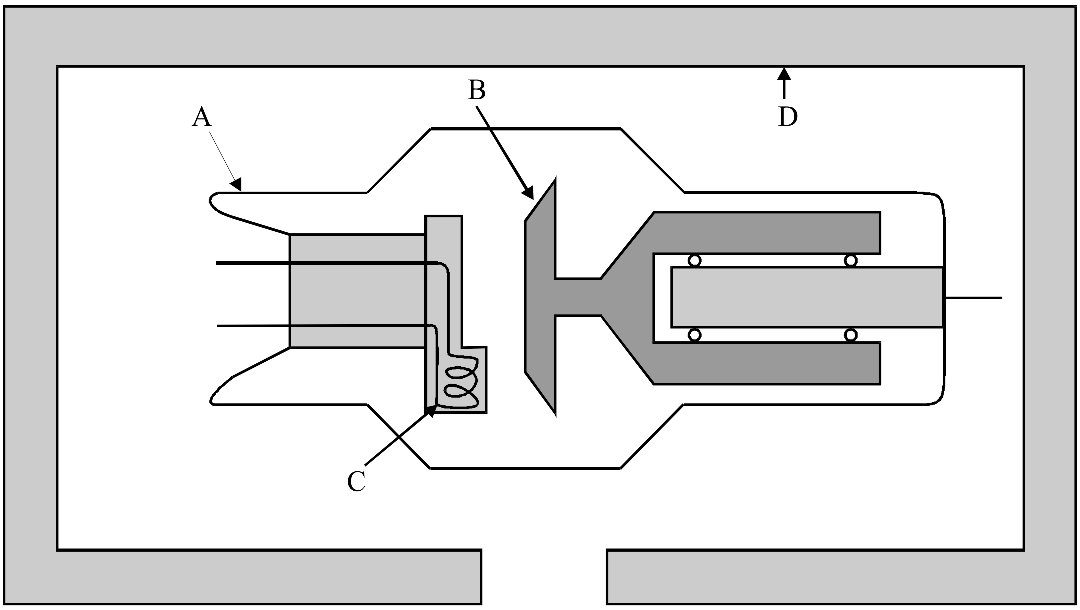
....

reason 2 ....

....

(4)
(Total 8 marks)

41. The simplified diagram shows a modern X-ray tube.



(a) For each of the labelled parts, state what it is and explain its purpose.

A name ....

purpose ....

....

B name ....

purpose ....

....

C name ....

purpose ....

....

D name ....

purpose ....

....

(8)

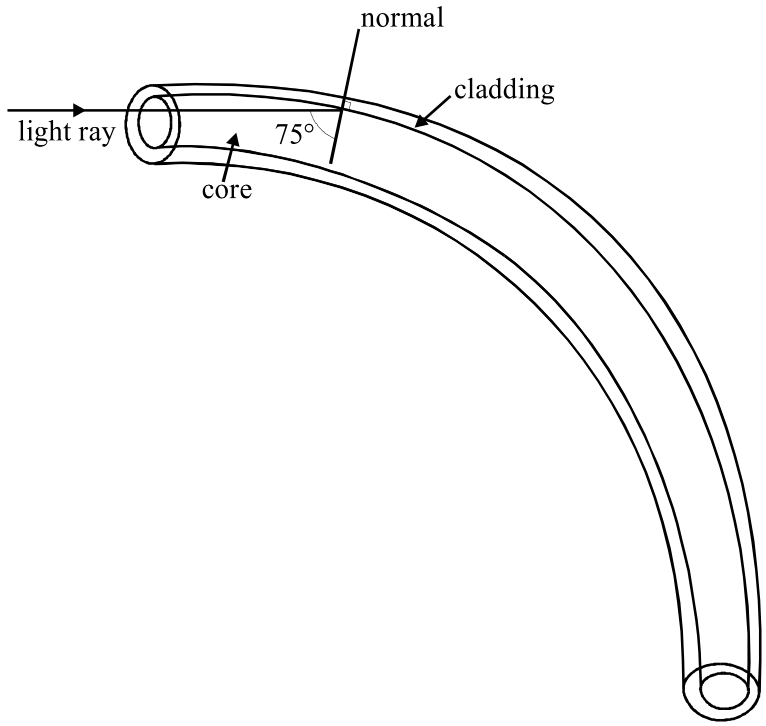
(b) On the diagram draw and label

(i) the direction of the electron beam,

(ii) the direction of the useful X-ray beam.

(2)
(Total 10 marks)

42. The diagram shows a glass optical fibre with a central core of refractive index 1.55 and a surrounding cladding of refractive index 1.40.



(a) Calculate the critical angle, C, for the boundary between these two types of glass.

....

....

....

....

....

(3)

(b) Complete the path of the light ray shown in the diagram.

(2)

(c) State and explain whether the following changes in the optical fibre would increase or decrease the probability of light escaping from the fibre.

(i) increasing the refractive index of the cladding

....

....

(ii) bending the fibre into a tighter curve

....

....

(3)
(Total 8 marks)

43. (a) Explain how a piezoelectric crystal is caused to generate waves of ultrasound.

....

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....

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....

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....

(4)

(b) In medical applications of ultrasound a short pulse of duration about 1 μs is often used.

(i) Explain why the pulse of ultrasound must be short.

....

....

....

(ii) Short voltage pulses applied to the piezoelectric crystal make it vibrate and emit *short* pulses only if the crystal assembly is modified. Explain the modification which is necessary.

....

....

....

(3)

(c) (i) Under what conditions is ultrasound reflected strongly at boundaries between two types of material?

....

....

(ii) State **two** physical properties of the materials which determine the proportion of ultrasound which is reflected at a boundary.

....

....

(iii) Explain what a coupling medium or gel is and why, and where, it is used.

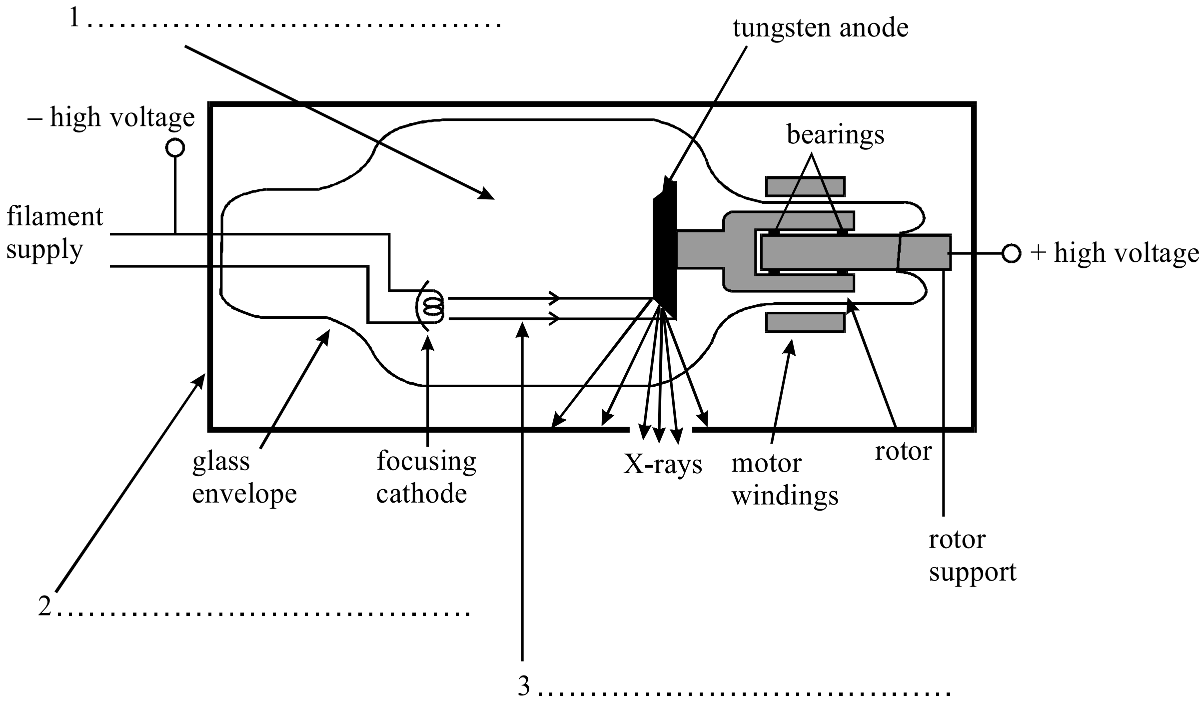
....

....

....

(5)
(Total 12 marks)

44. (a) The diagram shows a rotating-anode X-ray tube. Complete the labelling of the **three** numbered arrows in the diagram.



(3)

(b) Explain why the anode

(i) is rotated,

....

....

....

(ii) has a bevelled edge.

....

....

....

(3)

(c) Define for a material,

(i) the linear attenuation coefficient, μ,

....

....

....

(ii) the half-value thickness.

....

....

....

(2)

(d) A monochromatic X-ray beam of intensity 6.0 W m^{-2} is incident on an aluminium sheet of thickness 2.0 mm. For these X-rays, the half-value thickness of aluminium is 3.2 mm. Calculate the intensity of the transmitted beam.

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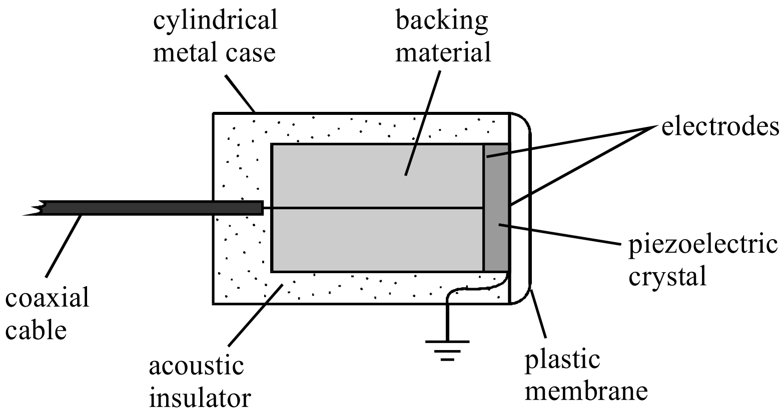
....

(3)
(Total 11 marks)

45. The diagram shows an ultrasound transducer as used in A-scans. The transducer produces short pulses of ultrasound.



(a) (i) Why is it necessary for the pulse to be short?

....

....

....

(ii) Explain, with reference to the diagram, the process by which the transducer produces short pulses.

You may be awarded marks for the quality of written communication provided in your answer.

....

....

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....

....

(5)

(b) State **one** advantage and **one** disadvantage of ultrasound compared with X-rays in medical imaging.

advantage: ....

....

disadvantage: ....

....

(2)
(Total 7 marks)

46. Diagnostic X-rays are produced using a rotating anode X-ray tube.

(a) (i) State **two** methods which can be used to increase the intensity of the X-ray beam produced by the tube.

method 1 ....

method 2 ....

(ii) For each method of increasing intensity, state the effect on the maximum X-ray photon energy.

method 1 ....

method 2 ....

(3)

(b) Before taking an X-ray photograph, the X-ray beam emerging from the tube is passed through an aluminium filter. State and explain the reason for filtering the X-rays.

....

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....

....

....

....

(3)

(Total 6 marks)

47. In the course of diagnosis and treatment of a child's broken arm, several images of the arm are required. Similarly, to check the progress of a woman's pregnancy, several images of the foetus are required. **In each case,** state which imaging technique would probably be used and give **two** reasons for the choice.

Broken arm:

technique used ....

reason 1 ....

....

reason 2 ....

....

Foetus:

technique used ....

reason 1 ....

....

reason 2 ....

....

(Total 4 marks)

48. An endoscope uses coherent and non-coherent optical fibre bundles.

(i) Describe the difference in structure between coherent and non-coherent bundles.

You may be awarded marks for the quality of written communication in your answer.

....

....

....

....

....

(ii) State the use of:

the coherent bundle ....………...............................…........

the non-coherent bundle ....

(iii) The fibres in the coherent bundle have very small diameters. State **two** advantages of using small diameter fibres.

advantage 1 ……..….....................................

....

....

advantage 2 ....……...

....

....

(Total 6 marks)

49. (i) Explain what is meant by the *half-value thickness* of lead for X-rays.

....

....

....

....

(ii) Calculate the linear attenuation coefficient of lead for 90 keV X-ray photons.

half value thickness of lead for 90 keV X-ray photons = 12mm.

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....

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....

(iii) Calculate the thickness of lead needed to reduce the intensity of a beam of 90 keV X-ray photons to 5.0 % of the intensity incident on the lead.

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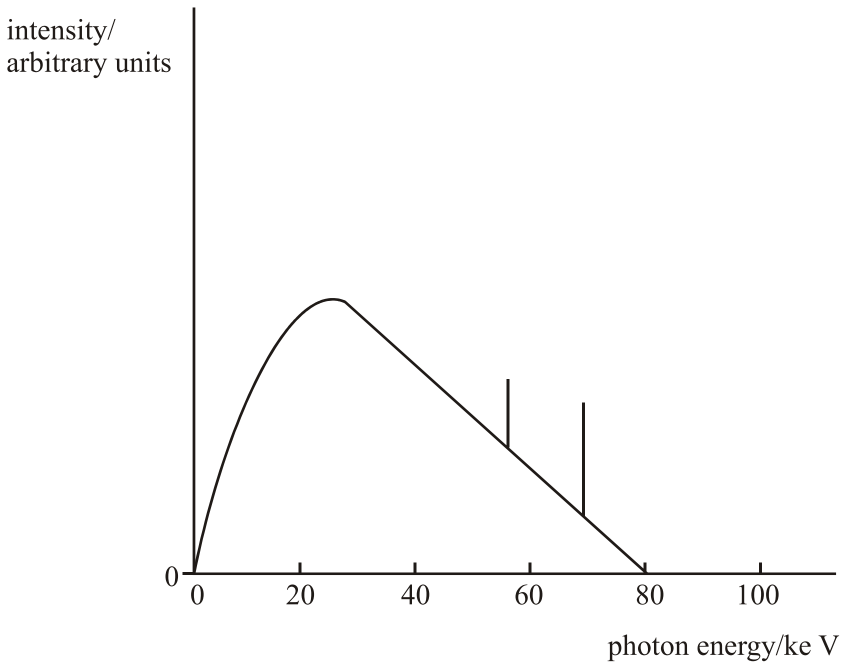
(Total 6 marks)

50.



(a) An X-ray tube operates with a pd across the tube of 80 kV. The figure above shows the X-ray spectrum emitted. Explain why the spectrum has spikes at specific photon energies.

....

....

....

....

(2)

(b) The pd across the tube is increased to 90 kV. Sketch on the figure above the X-ray spectrum produced at this new pd.

(3)

(c) At the working pd of 80 kV, the anode current was 120 mA. The X-ray tube has an efficiency of 0.70 %. Calculate the rate of production of heat at the anode.

....

....

....

....

(3)
(Total 8 marks)

Teacher Resource Bank

GCE Physics B: Physics in Context

Additional Sample Questions (Specification A)

Mark Scheme

PHYB4 – Physics Inside and Out

1. (a) (i) $\left(g = -\frac{\Delta V}{\Delta x}\right) 19 = (-)\frac{\Delta V}{10}$ gives $\Delta V = 190$ **(1)** J kg^{-1} **(1)**

(ii) $W(= m\Delta V) = 9.0 \times 190 = 1710$J [or $mgh = 9.0 \times 19 \times 10 = 1710$J] **(1)**

(iii) on mountain, required energy would be less
because gravitational field strength is less **(1)** **3**

(b) $g \propto \frac{1}{r^2}$ (or F $\propto \frac{1}{r^2}$ or correct use of $F = \frac{GMm}{r^2}$) **(1)**

$\therefore g' = \frac{19}{2^2} = 4.75(\text{Nkg}^{-1})$ **(1)** **2**

[5]

2. (a) (i) –31 MJ kg^{-1} **(1)**

(ii) increase in potential energy = $m\Delta V$ **(1)**
$= 1200 \times (62 - 21) \times 10^6$ **(1)**
$= 4.9 \times 10^{10}$ J **(1)** **4**

(b) (i) $g = -\frac{\Delta V}{\Delta x}$ **(1)**

(ii) g is the gradient of the graph = $\frac{62.5 \times 10^6}{4 \times 6.4 \times 10^6}$ **(1)**
$= 2.44$ N kg^{-1} **(1)**

(iii) $g \propto \frac{1}{R^2}$ and R is doubled **(1)**

expect g to be $\frac{9.81}{4} = 2.45$ N kg–^{1} **(1)**

[*alternative (iii)*
$g \propto \frac{1}{R^2}$ and R is halved **(1)**

expect g to be $2.44 \times 4 = 9.76$ N kg^{-1} **(1)** 5

[9]

3. D **(1)**

4. C **(1)**

5. D **(1)**

6. (a) period = 24 hours or equals period of Earth's rotation **(1)**
remains in fixed position relative to surface of Earth **(1)**
equatorial orbit same angular speed as Earth or equatorial surface **(1)** max 2

(b) (i) $\frac{GMm}{r^2} = m\omega^2 r$ **(1)**

$T = \frac{2\pi}{\omega}$ **(1)**

$r\left(= \frac{GMT^2}{4\pi^2}\right)^{1/3} = \left(\frac{6.67\times10^{-11}\times6\times10^{24}\times(24\times3600)^2}{4\pi^2}\right)^{1/3}$ **(1)** 3

(gives $r = 42.3 \times 10^3$ km)

(ii) $\Delta V = GM\frac{1}{R} - \frac{1}{r}$ **(1)**

$= 6.67 \times 10^{-11} \times 6 \times 10^{24} \times \left(\frac{1}{6.4\times10^6} - \frac{1}{4.23\times10^7}\right) =$

5.31×10^7 (J kg^{-1}) **(1)**

$\Delta E_p = m\Delta V$ (= $750 \times 5.31 \times 10^7$) = 3.98×10^{10} J **(1)**
(allow C.E. for value of ΔV)

[alternatives:
calculation of $\frac{GM}{R}$ (6.25×10^7) or $\frac{GM}{r}$ (9.46×10^6) **(1)**

or calculation of $\frac{GMm}{R}$ (4.69×10^{10}) or $\frac{GMm}{r}$ (7.10×10^9) **(1)**

calculation of both potential energy values **(1)**
subtraction of values or use of $m\Delta V$ with correct answer **(1)** 3
[8]

7. C **(1)**

8. A **(1)**

9. B **(1)**

10. (a) work = force × distance moved in direction of force **(1)**
(in circular motion) force is perpendicular to displacement **(1)**
no movement in direction of force **(1)** (hence no work)
[or speed of body remains constant (although velocity changes) **(1)**
kinetic energy is constant **(1)**
potential energy is constant **(1)**]

[or gravitational force acts towards the Earth **(1)**
Moon remains at constant distance/radius from Earth **(1)**
since radius is unchanged, gravitational force does no work
or E_p of Moon is constant] **(1)** 3
QWC 1 mark

(b) (i) any suitable example of circular motion **(1)**

(ii) any SHM example at maximum displacement **(1)** 2
[or any other suitable example, e.g. car starts from rest]

[5]

11. (a) (i) h (= ct) (= $3.0 \times 10^8 \times 68 \times 10^{-3}$) = $2.0(4) \times 10^7$ m **(1)**

(ii) $g = (-)\dfrac{GM}{r^2}$ **(1)**

r (= $6.4 \times 10^6 + 2.04 \times 10^7$) = 2.68×10^7 (m) **(1)**
(allow C.E. for value of h from (i) for first two marks, but not 3rd)

$g = \dfrac{6.67\times10^{-11}\times6.0\times10^{24}}{(2.68\times10^7)^2}$ (= 0.56 N kg^{-1}) **(1)** 4

(b) (i) $g = \dfrac{v^2}{r}$ **(1)**

$v = [0.56 \times (2.68 \times 10^7)]^{½}$ **(1)**
$= 3.9 \times 10^3$ m s^{-1} (3.87×10^3 m s^{-1}) **(1)**
(allow C.E. for value of r from a(ii)

[or $v^2 = \dfrac{GM}{r} =$ **(1)**

$v = \left(\dfrac{6.67\times10^{-11}\times6\times10^{24}}{2.68\times10^7}\right)^{1/2}$ **(1)**

$= 3.9 \times 10^3$ m s^{-1}] **(1)**

(ii) $T\left(=\dfrac{2\pi r}{v}\right) = \dfrac{2\pi\times2.68\times10^7}{3.87\times10^3}$ **(1)**

$= 4.3(5) \times 10^4$ s (12.(1) hours) **(1)**
(use of $v = 3.9 \times 10^3$ gives $T = 4.3(1) \times 10^4$ s = 12.0 hours)
(allow C.E. for value of v from (I)

[alternative for (b):

(ii) $T^2 = \left(\dfrac{4\pi^2}{GM}\right)r^3$ **(1)**

$\left(= \dfrac{4\pi^2}{6.67\times10^{-11}\times6.0\times10^{24}}\times(2.68\times10^7)^3\right)$ = (1.90×10^9 (s^2) **(1)**

$T = 4.3(6) \times 10^4$ s **(1)**

(i) $v\left(\dfrac{2\pi r}{T}\right) = \dfrac{2\pi\times2.68\times10^7}{4.36\times10^4}$ **(1)**

$= 3.8(6) \times 10^3$ m s^{-1} **(1)**]

(allow C.E. for value of r from (a)(ii) and value of T) 5

[9]

12. (a) (i) $\lambda = \dfrac{3.0\times10^8}{1200\times10^6}$ = (0.25 (m)) **(1)**

angular width $\left(=\dfrac{\lambda}{d}\right) = \dfrac{0.25}{1.8}$ = 0.14 (rad) **(1)**

= 8.0° **(1)**

(ii) beam width at 15 000 km = 0.14 × 15 000 (km) (= 2100 km) **(1)** 4

(b) (i) gravitational force on satellite of mass $m = \dfrac{GMm}{(R+h)^2}$ **(1)**

centripetal acceleration = $\dfrac{v^2}{(R+h)}$ **(1)**

for a circular orbit, $\dfrac{GMm}{(R+h)^2} = \dfrac{mv^2}{(R+h)}$

(hence $v = \left(\dfrac{GM}{(R+h)}\right)^{1/2}$) **(1)**

(ii) $v = \left(\dfrac{6.67\times10^{-11}\times6.0\times10^{24}}{6.4\times10^6+15\times10^6}\right)^{1/2}$ **(1)**

$= 4.3(2)\times10^3$ m s^{-1} **(1)**

time period (= $\dfrac{2\pi r}{v}$) = $\dfrac{2\pi\times21.4\times10^6}{4.3\times10^3}$ **(1)**

= 3.1(3) s **(1)**

(allow C.E. for values of v)

(iii) beam speed across surface $\left(=\dfrac{\text{Earth's circumference}}{\text{time period}}\right)$

$= \dfrac{2\pi\times6.4\times10^6}{3.1\times10^4}$ (= 1.3×10^3 m s^{-1}) **(1)**

contact time $\left(=\dfrac{\text{beam width}}{\text{speed}}\right) = \dfrac{2.1\times10^6}{1.3\times10^3}$ (= 1615 s = 27 min) **(1)** 9

[13]

13. A **(1)**

14. (a) attractive **force** between point masses **(1)**
proportional to (product of) the masses **(1)**
inversely proportional to square of separation/distance apart **(1)** 3

(b) $m\omega^2R = (-)\dfrac{GMm}{R^2}\left(\text{or} = \dfrac{mv^2}{R}\right)$ **(1)**

(use of $T = \dfrac{2\pi}{\omega}$ gives) $\dfrac{4\pi^2}{T^2} = \dfrac{GM}{R^3}$ **(1)**

G and M are constants, hence $T^2 \propto R^3$ **(1)** 3

(c) (i) (use of $T^2 \propto R^3$ gives) $\dfrac{365^2}{(1.50\times10^{11})^3} = \dfrac{T_m^2}{(5.79\times10^{10})^3}$ **(1)**

T_m = 87(.5) days **(1)**

(ii) $\dfrac{1^2}{(1.50\times10^{11})^3} = \dfrac{165^2}{R_N^3}$ (gives $R_N = 4.52\times10^{12}$ m) **(1)**

ratio = $\dfrac{4.51\times10^{12}}{1.50\times10^{11}}$ = 30(.1) **(1)** 4

[10]

15. (a) orbits (westwards) over Equator **(1)**
maintains a fixed position relative to surface of Earth **(1)**
period is 24 hrs (1 day) or same as for Earth's rotation **(1)**
offers uninterrupted communication between transmitter and receiver **(1)**
steerable dish not necessary **(1)** Max 3
QWC **(1)**

(b) (i) $G\dfrac{Mm}{(R+h)^2} = mw^2(R+h)$ **(1)**

use of $w = \dfrac{2\pi}{T}$ **(1)**

(ii) gives $\dfrac{GM}{(R+h)^3} = \dfrac{4\pi^2}{T^2}$, hence result **(1)**

(iii) limiting case is orbit at zero height i.e. $h = 0$ **(1)**

$T^2 = \left(\dfrac{4\pi^2 R^3}{GM}\right) = \dfrac{4\pi^2\times(6.4\times10^6)^3}{6.67\times10^{-11}\times6.0\times10^{24}}$ **(1)**

T = 5090 s (= 85 min) **(1)** 6

(c) speed increases **(1)**

loses potential energy but gains kinetic energy **(1)**

[or because $v^2 \propto \dfrac{1}{r}$ from $\dfrac{GMm}{r^2} = \dfrac{mv^2}{r}$]

[or because satellite must travel faster to stop it falling inwards when gravitational force increases] 2

[11]

16. B **(1)**

17. B **(1)**

18. (a) (i) *free:* system displaced and left to oscillate **(1)**

(ii) *forced:* oscillation due to (external) periodic driving force [or oscillation at the frequency of another vibrating system] **(1)** 2

(b) (i) $k = \frac{3000}{5.0 \times 10^{-2}} = 6.0 \times 10^4\ \text{Nm}^{-1}$ **(1)**

(ii) $T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{9000}{g \times 6.0 \times 10^4}}$ **(1)**

giving 0.78 s **(1)** 3

(c) (i) $t = \frac{s}{v} = \frac{16}{20} = 0.80$ s **(1)**

(ii) time ≅ period of free oscillations, resonance **(1)**

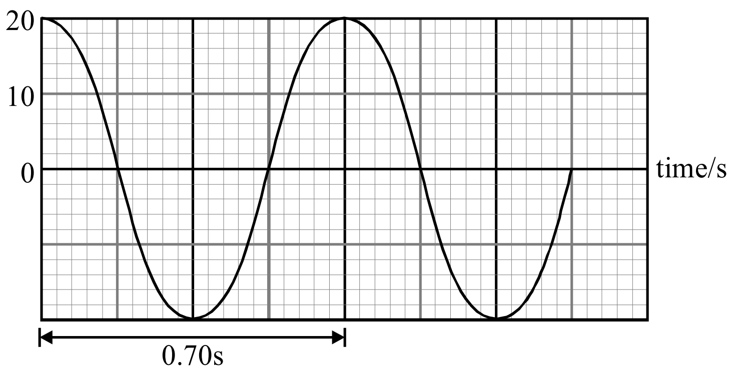
i.e. large amplitude oscillations **(1)** 3

[8]

19. (a) (i) $k = \frac{2.0}{50 \times 10^{-3}}$ **(1)**

$T = 2\pi\sqrt{\frac{0.5}{40}} = 0.70$ s **(1)**

(ii)



a correct (= 20mm) **(1)**

$x = \pm 20$ mm at $t = 0$ **(1)**

T correct (= 0.70 s) **(1)** 5

(b) (i) vibrates at 0.5 Hz with low amplitude **(1)** 1

(ii) vibrates with high amplitude **(1)**

at natural frequency **(1)**

resonates **(1)** max 2

[8]

20. C **(1)**

21. A **(1)**

22. B **(1)**

23. (a) acceleration is proportional to displacement **(1)**
acceleration is in opposite direction to displacement, or towards a fixed point, or towards the centre of oscillation **(1)** 2

(b) (i) $f = \frac{25}{23} = 1.1$ Hz (or s^{-1}) (1.09 Hz) **(1)**

(ii) (use of $a = (2\pi f)^2 A$ gives)

$a = (2\pi \times 1.09)^2 \times 76 \times 10^{-3}$ **(1)**

$= 3.6$ m s^{-2} (3.56 m s^{-2}) **(1)**

(use of $f = 1.1$ Hz gives $a = 3.63$ m s^{-2})
(allow C.E. for incorrect value of f from (i))

(iii) (use of $x = A\cos(2\pi ft)$ gives) $x = 76 \times 10^{-3}\cos(2\pi \times 1.09 \times 0.60)$ **(1)**
$= (–)4.3(1) \times 10^{-2}$m ((43 mm) **(1)**

(use of $f = 1.1$ Hz gives $x = (–)4.0(7) \times 10^{-2}$ m (41 mm))
direction: above equilibrium position or upwards **(1)** 6

(c) (i) graph to show:

correct shape, i.e. cos curve **(1)**

correct phase i.e. –(cos) **(1)**

(ii) graph to show:
two cycles per oscillation **(1)**

correct shape (even if phase is wrong) **(1)**

correct starting point (i.e. full amplitude) **(1)** max 4
[12]

24. (a) (i) $mg = ke$ **(1)**

$k = \left(\frac{0.25 \times 9.81}{40 \times 10^{-3}}\right) = 61(.3)$ N m^{-1} **(1)**

$T\left(= 2\pi\sqrt{\frac{m}{k}}\right) = 2\pi\sqrt{\frac{0.69}{61.3}}$ (= 0.667 s) **(1)**

(ii) $f\left(= \frac{1}{T}\right) = \frac{1}{0.667}$ (= 1.50 Hz) **(1)**

(b) (i) forced vibrations (at 0.2 Hz) **(1)**
amplitude less than resonance (≈ 30 mm) **(1)**
(almost) in phase with driver **(1)**

(ii) resonance [or oscillates at 1.5 Hz] **(1)**
amplitude very large (> 30 mm) **(1)**

			oscillations may appear violent	**(1)**	
			phase difference is 90º	**(1)**	
		(iii)	forced vibrations (at 10 Hz)	**(1)**	
			small amplitude	**(1)**	
			out of phase with driver [or phase lag of (almost) π on driver]	**(1)**	Max 6
					[10]
25.	C			**(1)**	
26.	(a)	(i)	$\omega_2 = \dfrac{90 \times 2\pi}{60} = 9.4$ (rad s^{-1})	**(1)**	
			$\alpha \left(= \dfrac{\omega_2 - \omega_1}{t} \right) = \dfrac{9.4}{8.0}$ (= 1.18 rad s^{-2})	**(1)**	
		(ii)	$T(= I\alpha) = 250 \times 1.18 = 295$ or 300 N m	**(1)**	
		(iii)	k.e. $\left(= \dfrac{1}{2} I\omega^2 \right) = \dfrac{1}{2} \times 250 \times 9.4^2 = 1.1 \times 10^4$ J	**(1)**	
		(iv)	power $\left(= \dfrac{\text{change in kinetic energy}}{\text{time}} \right) = \dfrac{1.1 \times 10^4}{8.0} = 1.4$ kW	**(1)**	5
	(b)	(i)	$\theta = 32 \times 2\pi = 200$(rad)	**(1)**	
			$\omega_2^2 = \omega_1^2 + 2\alpha\theta$	**(1)**	
			$\alpha = \dfrac{(9.4)^2}{2 \times 200} = 0.221$(rad s^{-2})	**(1)**	
			$T(= I\alpha) = 55$ N m	**(1)**	
		(ii)	$P(= T\omega) = 55 \times 9.4 = 520$ W	**(1)**	5
					[10]
27.	(a)	$I_1\omega_1 = I_2\,\omega_2$		**(1)**	
		$\omega_2 = \dfrac{1.6 \times 5.0}{1.85} = 4.3$ (2) rad s^{-1}		**(1)**	2
	(b)	(i)	1/4 turn = π/2 radians	**(1)**	
			$\omega_2^2 = \omega_1^2 + 2\alpha\theta$ giving $5.0^2 = 4.32^2 + 2\alpha\pi/2$ giving $\alpha = 2.0(2)$ rad s^{-2}		**(1)**
			(allow C E. from (a))		
		(ii)	torque needed $T = I\alpha = 1.85 \times 2.02 = 3.7(3)$ (N m)	**(1)**	
			(allow C.E. from (b)(i))		
			torque = force × radius, giving force = $\dfrac{3.73}{0.31} = 12$ N	**(1)**	
			(allow C.E. from value of torque needed)	4	
					[6]
28.	(a)	(i)	$\alpha \left(= \dfrac{\omega_2 - \omega_1}{t} \right) = \dfrac{1100 - 0}{4.2} = 260$ rad s^{-2} (262 rad s^{-2})	**(1)**	

(ii) T (= $I\alpha$) = 7.6 × 10^{-4} × 262 = 0.20 N m **(1)** 2

(b) $I_{\text{liquid}} = 8 \times (3.0 \times 10^{-3}\ (84 \times 10^{-3})^2 = 1.7 \times 10^{-4}$ (kg m^2) **(1)**

$I_{\text{total}} = 7.6 \times 10^{-4} + 1.7 \times 10^{-4} = 9.3 \times 10^{-4}$ (kg m^2) **(1)**

$\alpha\left(=\frac{T}{I}\right)=\frac{0.20}{9.3\times10^{-4}} = 215$ (rad s^2) **(1)**

$t\left(=\frac{\omega_2-\omega_1}{\alpha}\right) = \frac{1100}{215}$ (= 5.1 s) **(1)**

(allow C.E for value of I_{liquid}) 3

(c) $\theta_1\left(=\frac{(\omega_1+\omega_2)}{2}t\right) = \frac{1100}{2} \times 5.0 = 2750$ (rad)

$\theta_3 = \frac{1100}{2} \times 6.0 = 3300$ (rad) (for both θ_1 and θ_3) **(1)**

θ_2 (= $\omega_2 t$) = 1100 × (60 – 11) = 53900 (rad) **(1)**

total angle turned = $\theta_1 + \theta_2 + \theta_3 = 60 \times 10^3$ rad **(1)** 3

[8]

29. (a) (i) torque = force × diameter **(1)**

= 0.12 × 0.34 = 4.1 × 10^{-2}Nm **(1)**

(ii) (use T=Ia gives) $\alpha = \frac{4.1\times10^{-2}}{0.17}$ **(1)**

(= 0.24 rads^{-2}) 3

(b) (i) (use of $w_2 = w_1 + \propto t$ gives) 0 = 0.92 – 0.24 t and t = 3.8(3)s **(1)**

(ii) (use of $w_2^2 = w_1^2 - 2a\theta$ gives) 0 = 0.92^2 – (2 × 0.24 × θ) **(1)**

θ = (1.7(6) rad) = $\left(1.76\times\frac{360}{2\pi}\right) 101^{(o)}$ **(1)**

[or $\theta = w_1 t - \frac{1}{2}\propto t^2$} 3

[6]

30. B **(1)**

31. A **(1)**

32. C **(1)**

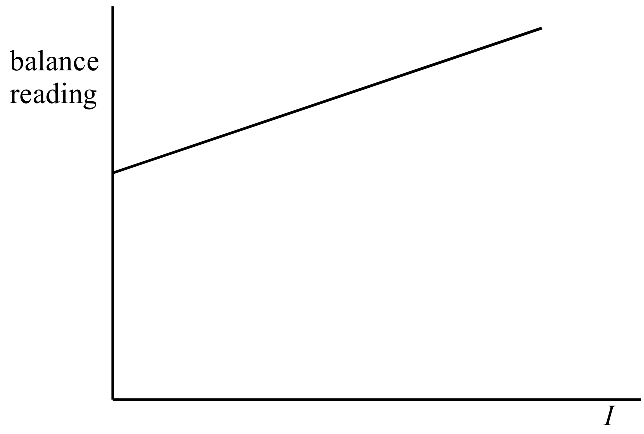
33. D **(1)**

34. (a) (i) interaction between current and B-field gives force on wire **(1)**
equal and opposite force on magnet (down) **(1)**

(ii) force on wire must be up **(1)**
∴ current right to left **(1)**
by left hand rule **(1)**

(iii) (force = $BIl = mg$ = change in mass × 9.8)
$B \times 5.0 \times 0.060 = 1.54 \times 10^{-3} \times 9.8$ **(1)**
B = 0.050 T [50.3 mT] **(1)** max 6

(b)



straight line **(1)**
intercept, upward slope **(1)** 2
[8]

35. B **(1)**

36. A **(1)**

37. D **(1)**

38. C **(1)**

39. (a) greater flux (linkage) or more flux lines (at same distance)
[or stronger magnet produces flux lines closer together] **(1)**
greater rate of change of flux (linkage)
[or more flux lines cut per unit time] **(1)**
emf ∝ rate of change of flux (linkage) **(1)**

[or using $\in = N\frac{\Delta\phi}{\Delta t}$, where $\Delta\Phi = A\,\Delta B$, v and Δt are the same **(1)**

ΔB is larger since magnet is stronger **(1)**

N and A are constant, $\therefore \in$ is larger **(1** max 3

(b) (i) area swept out, $\Delta A = lv\Delta t$ **(1)**

$\Delta \Phi (= B\Delta A) = Blv\,\Delta t$ **(1)**

$\in \left(= (N)\dfrac{\Delta\phi}{\Delta t} \right) = \dfrac{Blv\Delta t}{\Delta t}$ gives result **(1)** 3

(c) (i) $w(=2\pi f) = 2\pi \times 16$ **(1)**

$= 101$ rads^{-1} **(1)**

(ii) $v(=rw) = 32 \times 10^{-3} \times 101 = 3.2(3)$ms^{-1} **(1)**

(allow C.E. for value of w from (i)) **(1)**

(iii) $\in (= Blv) = 28 \times 10^{-3} \times 64 \times 10^{-3} \times 3.23$ **(1)**

$= 5.7(9) \times 10^{-3}$V **(1)** 5

(allow C.E. for values of v from (ii))

(solutions using $\in = Bfnr^2$ to give $5.7(6) \times 10^{-3}$ V acceptable)

[11]

40. (a) *coherent bundle:*
fibres maintained in fixed positions relative to each other **(1)**
non-coherent bundle:
fibres have no fixed relative positions **(1)** 2

(b) coherent bundles of fibres transmit images (of internal organs of the body) **(1)**
non-coherent bundles transmit (or conduct) light
(to inside the human body for illumination) **(1)** 2

(c) (i) high resolution [or fine detail can be seen] (*)
very flexible bundle (*)
finer fibres allow bending round tighter curves without escape of light (*)
(*) any two **(1)(1)**

(ii) so that scratches on the outer surface do not allow light to escape **(1)**
so that close contact between adjacent fibres
[or liquid penetrating between fibres]
does not allow light to pass from one fibre to
another to ensure that image is not confused
(*alternatives* :corrupted, scrambled) as a result of
light passing between individual fibres
[or to prevent (mechanical) damage to surface of core e.g scratches]) **(1)** 4

[8]

41. (a) A glass tube **(1)**
(sealed), evacuated, allows electrons to travel unimpeded **(1)**

B rotating anode [or target] **(1)**
rotation of anode [or target] to spread heated area **(1)**
target which emits X-rays when hit by (energetic) electrons **(1)** max 2

C filament [or cathode] **(1)**
heat source to release electrons from surface of cathode by thermionic emission **(1)**

D lead housing **(1)**
prevent X-rays from escaping in unwanted directions **(1)** max 8

(b) path of electrons shown from filament (C) to anode (B) **(1)**
path of X-rays shown starting at anode (B)
and emerging through window in lead housing (D) **(1)** 2
[10]

42. (a) $\frac{\sin i}{\sin r} = \frac{\sin C}{l}$ **(1)** $= \frac{1.40}{1.55} = 0.903$ **(1)**
angle $C = 64.6°$ **(1)** 3

(b) on outer edge only of core **(1)**
two to four reflections **(1)**
[no marks for zig-zag] 2

(c) (i) smaller difference between the core index and cladding index makes critical angle larger **(1)**
therefore increases the chance of light escaping **(1)**

(ii) makes internal angle of incidence at core-cladding interface more likely to be less than the critical angle **(1)**
therefore increases the chance of light escaping **(1)** max 3
[8]

43. (a) two faces of a thin slice of crystal (coated with a thin layer of silver) act as electrodes **(1)**
electrodes connected to <u>high frequency</u> (several MHz) source of e.m.f. **(1)**
as applied e.m.f. alternates it applies alternating (rapidly reversing direction) electric field across the slice of crystal between the electrodes **(1)**
crystal expands and contracts at the same frequency as the applied e.m.f. **(1)**
the vibrations of the faces of the crystal slice produce ultrasound pressure waves **(1)** max 4

(b) (i) pulse short compared with the transit time **(1)**
pulses are used for timing echoes which give measurements of depth in the body **(1)**
pulse must be short enough to ensure the leading edge returns after the trailing edge departs **(1)**

(ii) behind the crystal a vibration-absorbing backing material is attached **(1)**
this stops the vibrations quickly after the electrical signal is stopped, ensuring that the pulse is short **(1)** max 3

(c) (i) when there is a large difference in acoustic impedance
[or significant change in density or significant change in elasticity or texture of tissue] **(1)**

(ii) tissue density **(1)**
tissue elasticity/texture **(1)**

(iii) ultrasound is reflected back at boundaries with air
[or replacement of air prevents reflection] (*)
gel between transducer and skin
(prevents loss of signal due to boundary reflection) (*)

acoustically well -matched gel gives good transmission
(with minimum reflection at skin boundary) (*)

(*) any two **(1) (1)** 5
[12]

44. (a) 1: vacuum/evacuated (tube) **(1)**
2: lead (lined shield) **(1)**
3: electrons (beam) **(1)** 3

(b) (i) heat is spread over a greater volume/area/section **(1)**
thus allows more energetic X-rays to be produced
[or allows X-rays to be generated for longer] **(1)**

(ii) (bevelled edge) gives larger target area **(1)**
but small source area (to produce sharp image) **(1)** max 3

(c) (i) the fraction of X-rays removed per unit thickness of the material **(1)**

(ii) the thickness of the material which will reduce the intensity
to half its original level **(1)**
for a specified energy of the X-rays (in either (i) or (ii)) **(1)** 2

(d) (use of $\mu = \frac{\ln 2}{t_{1/2}}$ gives) $\mu = \frac{\ln 2}{3.2} = 0.22\ \text{mm}^{-1}$ ($0.217\ \text{mm}^{-1}$) **(1)**
(use of $I = I_o\, e^{-\mu x}$ gives) $I = 6.0 \times e^{-0.217 \times 2}$ **(1)**
(allow C.E. for value of μ)
$= 3.9\ \text{W m}^{-2}$ **(1)** 3
[11]

45. (a) (i) probe is used as a generator and receiver **(1)**

(ii) electrodes connected to (high frequency/alternating) emf **(1)**
crystal expands and contracts at frequency of emf **(1)**
vibration of faces produce ultrasound (pressure) waves **(1)**
backing material damps oscillation of crystal **(1)**
to stop crystal oscillating between end of transmitted pulse
and start of received pulse **(1)** max 5

The quality of Written communication marks were awarded for quality of
answers to this question **(2)**.

(b) advantage: e.g. not harmful to living cells or soft tissue **(1)**
disadvantage: e.g. cannot penetrate bone or low resolution **(1)** 2
[7]

46. (a) (i) method 1: increasing pd across the tube **(1)**
method 2: increasing tube current or increasing filament temperature **(1)**

(ii) method 1: will increase the maximum photon energy **(1)**
method 2: will not change the maximum photon energy **(1)** max 3

(b) reduces intensity of low energy photons **(1)**
hardly changes intensity of high energy photons **(1)**
need high energy for picture
[or low energy no good for picture] **(1)**
reducing low energy reduces dose received by patient **(1)** max 3
[6]

47. technique: broken arm – X-ray, foetus – ultrasound **(1)**

reasons: (X-ray) good contrast
sharp image
good resolution any two **(1)** **(1)**

(ultrasound) non-ionising (safe)
detects change in tissue type
allows real-time image any two **(1)** **(1)** max 4

[4]

48. (i) coherent: fibres maintain positions at both ends **(1)**
non-coherent: fibres have random positions **(1)**

(ii) carry images **(1)**
carry light into the body **(1)**

(iii) more flexible **(1)**
image has better definition **(1)** 6

[6]

49. (i) thickness needed to reduce intensity by half **(1)**
for X-rays of specific energy **(1)**

(ii) $\mu = \dfrac{\ln 2}{x}$ **(1)**

$= 58\ \text{m}^{-1}$ ($57.8\ \text{m}^{-1}$) **(1)**

(iii) (use of $I = I_0 e^{-\mu x}$ gives) $0.05 = e^{-57.8x}$ **(1)**
$x = 0.052$ m (or 52 mm) (51.8 mm) **(1)**
(allow C.E. for value of μ from (ii)) 6

[6]

50. (a) specific to anode element/target atoms/material **(1)**
energy level transition **(1)** 2

(b) new curve to show:
entire curve has more intensity **(1)**
stops at 90 kV **(1)**
spikes in same position **(1)** 3

(c) % into heat = (100 – 0.70) = 99.3 **(1)**

rate of heat produced = $\dfrac{99.3}{100} \times 80 \times 10^{3} \times 120 \times 10^{-3}$ **(1)**

= 9.5 kW **(1)** (9.53 kW) 3

[8]