PHYSICS 2009

YEAR 12

Solutions

Section A: Short Answers
Marks allocated: 60 marks out of a total of 200 (30%)

1. (a) $v = f\lambda \qquad 340 = f \times 0.68$

$$f = \frac{340}{0.68} = 500\,\text{Hz}$$

(b) 500 vibrations in 1 s 1 000 ms so in 200 ms will make

$$\frac{500 \times 200}{1000} = 100 \text{ Vibrations}$$

2. (a) Alternating current / ~~Direct current~~

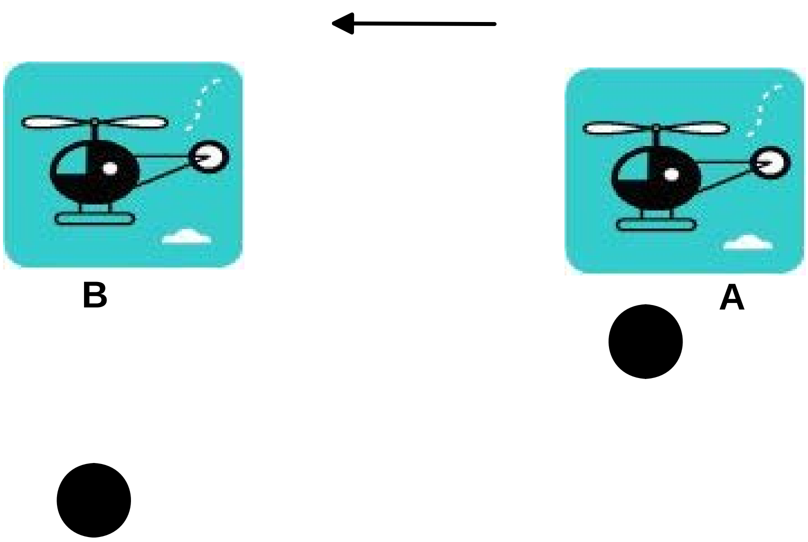
(b) Direct current would not allow the flux created in the primary to link in with the secondary coil and would result only in the primary becoming [very] hot.

3. (a) Energy is lost in the transmission cables as these have electrical resistance and are very long.
(b) If the voltage is high then the current can be reduced and the loss $I^2 R$ is reduced.

4. (a) Triangular struts distribute the load so that no one member has to have the strength to hold the entire weight. This means the jib can be lighter.

(b) Key idea is that the concrete block acts as a counter weight.

5.
(a)



(b) There is no horizontal acceleration so the horizontal speed of the package will remain unchanged.

6. (a)

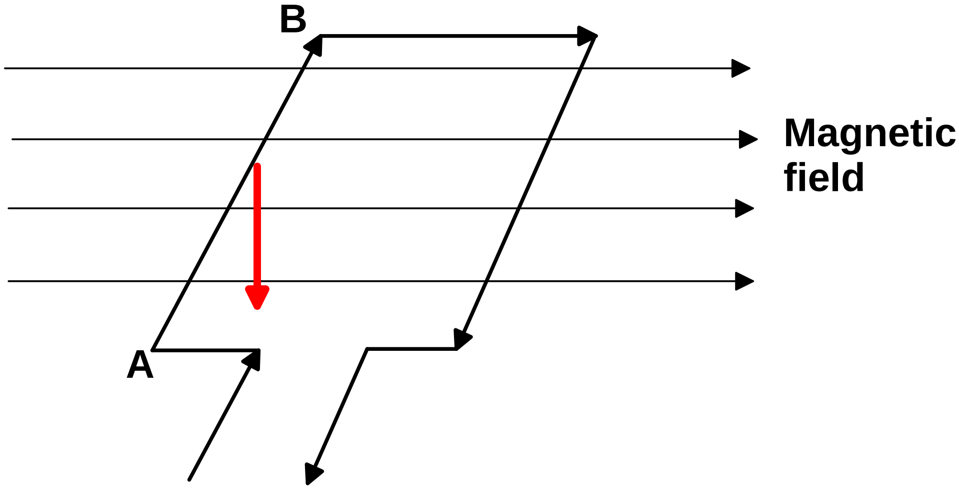
$$E = hf$$
$$= 6.63 \times 10^{-34} \times 10^{13}$$
$$= 6 \times 10^{-21}\,\text{J}$$

(allow frequency range of 10^{12} to 10^{14} Hz so E will have associated range)

(b)

$$\text{Number} = \frac{5}{6 \times 10^{-21}} = 10^{21} \text{ photons} \quad (\text{ again allow range})$$

7.

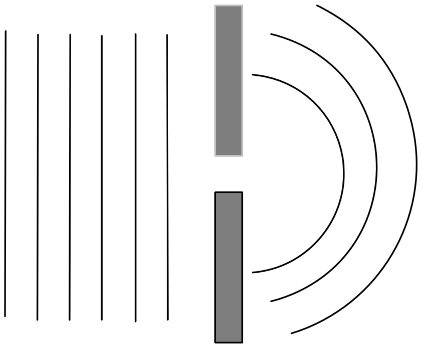


(a) see bold arrow.

(b)

$$F = BIL$$
$$= 0.55 \times 2.0 \times 0.40$$
$$= 0.44 \text{ N}$$

8. The following diagram shows wavefronts approaching a gap in a barrier.



(b) diffraction

(c) [i] Sound waves, [ii] Light waves, [iii] Could be either

9. (a)

$$55 = 10\log_{10}\frac{I}{10^{-12}}$$
$$I = 3.16 \times 10^{-7} \text{ W m}^{-2}$$
$$= 10\log\frac{10\left(3.16 \times 10^{-7}\right)}{10^{-12}} = 65 \text{ dB}$$

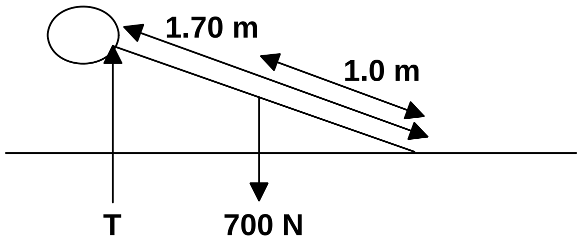
(b)

$I = 0.8 \times 10^{-7}\ \text{W m}^{2}$

$dB = 10 \log \frac{0.8 \times 10^{-7}}{10^{-12}}$

New level = 59 dB

10. Take moments about the foot,
Assume dimensions [allow variance]
Angle is small so can assume zero degrees



T x 1.7 = 700 x 1 Compression = 410 N
Allow range 350 – 500 N
[depends on location of centre of mass]

11. (a) Positive to attract the negatively charged electrons.

(b) $r = \frac{mv}{Bq} = \frac{9.11 \times 10^{-31} \times 3 \times 10^{7}}{0.2 \times 1.6 \times 10^{-19}} = 8.5 \times 10^{-4}\ \text{m}$

12. Key idea is ionisation. The electron beam has energy to ionise the gas in its path and the main emission line for neon is pink.

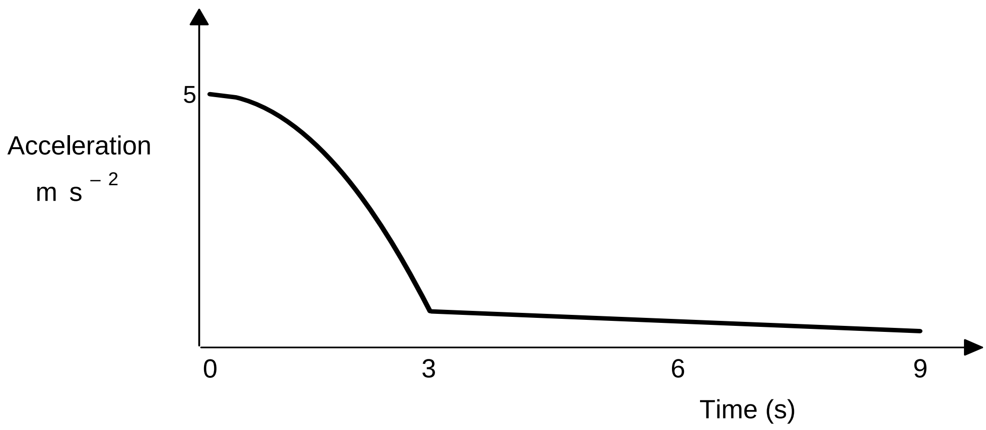
13.

$\text{Force} = \frac{mv^2}{r} + mg$ estimate $v = 3\ \text{m s}^{-1}$ and $r = 5$ m

$\text{Force} = \frac{60 \times (3)^2}{5} + 600$

$= 710\ \text{N}$

14. (a) Key idea is that after 3 s there is no acceleration, it all happens in first 30 m (3 s)



(b) Distance gone is equal to area under graph [assume triangle] $= \frac{(2 \text{ x } 9)}{2} = 9\,\text{m}$

15. Path difference is 37 – 20 = 17 m

$$v = f \text{ x } \lambda$$
$$340 = 680 \text{ x } \lambda$$
$$\lambda = 0.5\,\text{m}$$

(a) Path difference is integral number of wavelengths constructive interference so LOUD sound.

(b) As she moves the path difference will change so there will be areas of destructive and constructive interference so loud and softer sounds will be heard.

END OF SECTION A

Section B Problem Solving

1. (16 marks)

(a) u [horiz] = u cos ϕ u [vertical] = u sin ϕ (2)

(b) (3)

$$v = u + at$$
$$0 = -u\sin\phi + gt$$
$$t = \frac{u\sin\phi}{g}$$

(c)

$$s(\text{horiz}) = u\cos\phi \text{ x } t + 0 = \frac{u^2\cos\phi\sin\phi}{g}$$ (2)

(d)

$$s = \frac{50 \text{ x } 50 \text{ x } \sin 25 \text{ x } \cos 25}{9.8} = 97.7\,\text{m}$$ (3)

(e)

$$\text{Time} = \frac{2 \text{ x } 50\sin 25}{9.8} = 4.3\text{s}$$ (3)

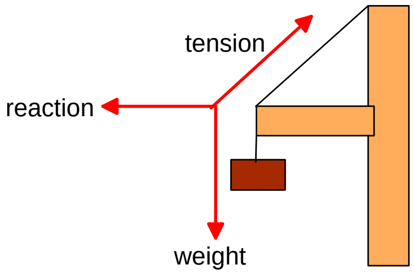
(f) Resolving vertically (down positive)

$$s = u\,t + 4.9\,t^2$$
$$1.0 = 50\sin 25 \text{ x } t + 4.9\,t^2$$ (3)
$$t = 0.047\,\text{s}$$

2. (a) Zero, the horizontal and vertical forces are equal in magnitude and opposite.

(1)

(b) (3)



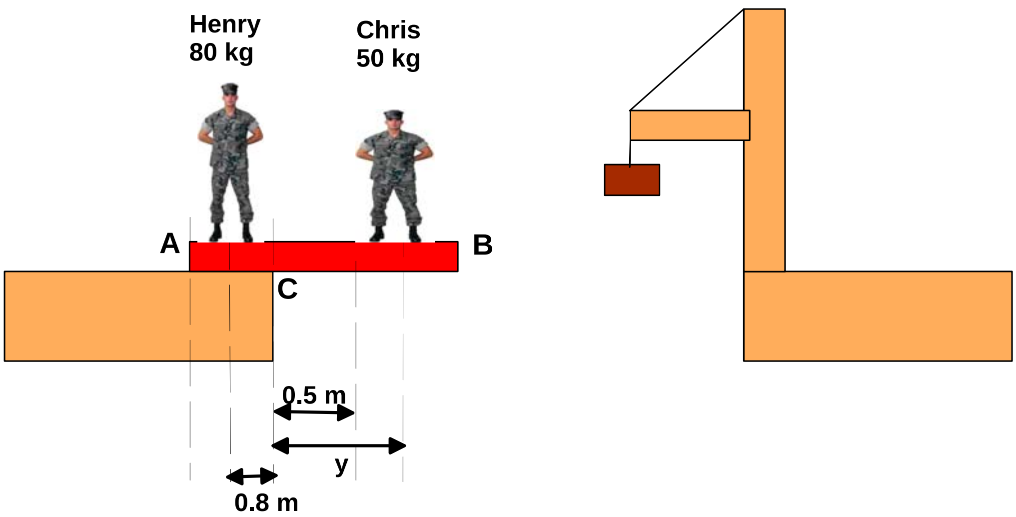
(c) Resolve vertically

T cos 45 = mg

T x 0.7071 = 19.6 N

T = 27.7 N (3)

(d)



Take moments about C

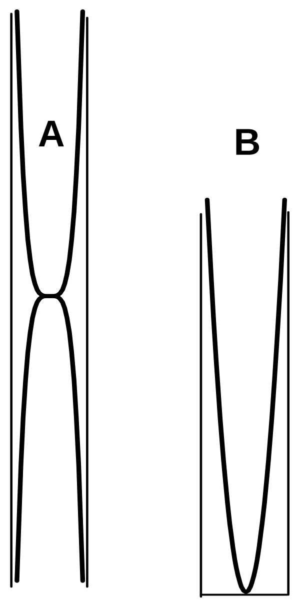
80 x 9.8 x 0.80 = 0.5 x 9.8 x 40 + 50 x 9.8 x y

64 = 20 + 50y

y = 0.88m

so distance to A is 1.88m (4)

3. (a)



(2)

(b)

$\lambda = 2 \times 5.09 = 10.18$

$$f = \frac{v}{\lambda} = \frac{346}{10.18} = 34 \text{ Hz}$$ (3)

(c)

$$f = \frac{346}{8.44} = 41 \text{ Hz}$$ (2)

(d) Beats of frequency 41 – 34 = 7 Hz (2)

(e) $\lambda = 4 \times \text{length} = 4 \times 4.8 = 19.2$ m

$$\text{Frequency} = \frac{346}{19.2} = 18 \text{ Hz}$$ (3)

4. (a) Key words are ; induction , magnetic flux change, movement (3)

(b) Magnetic field strength, speed of movement, direction of movement (2)

(c)

$$\text{Voltage} = \frac{1 \times 0.2 \times 0.05}{0.5} = 0.02 \text{ V}$$

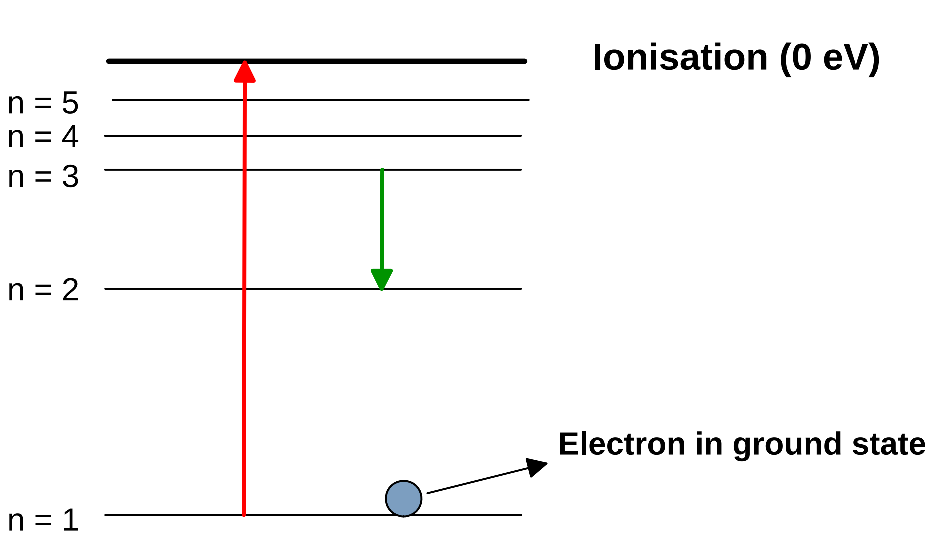
$$\text{Current} = \frac{0.02}{4} = 0.005 \text{ A or } 5.0 \text{ mA}$$ (4)

(d) Neat diagram showing

- Magnet , coil,
- Brushes (3)
- Rotation
- coil

Explain why the output is sinusoidal include cutting of field lines and that the direction of the induced current changes both in direction and magnitude. Show where is maximum and where is zero in any single rotation. (3)

5.



.

(a) Ionisation energy is energy needed to allow the electron to jump from the ground state to a state when it is no longer electrically bound to that atom (shown by line). Electron in ground state identified. (3)

(b) Line spectra are caused by changes in the energy of electrons. In any atom the electrons can only exist in discrete, unique to that atom energy levels. When an electron in an excited state drops in energy to a lower energy level it emits a photon of energy equal to the difference in energy levels. This according to Planks equation give a discrete frequency $\Delta E = h\,f$ (3)

(c) see line on diagram (1)

if $\lambda = 655$ nm then frequency $= \dfrac{3 \times 10^{8}}{655 \times 10^{-9}} = 4.58 \times 10^{14}$ Hz

$\Delta E = 6.63 \times 10^{-34} \times 4.58 \times 10^{14} = 3.04 \times 10^{-19}$ J (3)

6. (a) Key idea is gravity is less so rocket power can be significantly reduced. (1)

(b)

$$g = \frac{GM}{r^2}$$

$$3.73 = \frac{6.67 \times 10^{-11} \times 6.42 \times 10^{23}}{r^2}$$ (3)

$$r = 3.39 \times 10^{6} \text{ m}$$

(c)

$$\frac{mv^2}{r} = \frac{GmM}{r^2}$$

$$\frac{(2\pi r)^2}{t^2 r} = \frac{6.67 \times 10^{-11} \times 6.42 \times 10^{23}}{r^2}$$

$$t^2 = \frac{4\pi^2 (3.39 \times 10^6 + 150 \times 10^3)^3}{6.67 \times 10^{-11} \times 6.42 \times 10^{23}} = 40.6 \times 10^6$$ (4)

$$t = 6.38 \times 10^3 \text{ s} \qquad (1.77 \text{ h})$$

(d)

$$\frac{24}{1.77} = 13.5$$ (1)

(e) Any sensible answer that has a science curiosity aspect to it. (1)

7. (a) Resolve vertically

$2 T \sin 45 = 5.0 \times 9.8$

$T = 34.6$ N (3)

(b)

$$YM = 1.16 \times 10^{11} = \frac{FL}{A \times \Delta L} = \frac{34.6 \times 2}{\pi (1.5 \times 10^{-3})^2 \times \Delta L}$$ (4)

$$\Delta L = \frac{69.2}{\pi (1.5 \times 10^{-3})^2 \times 1.16 \times 10^{11}} = 0.85 \times 10^{-4} \text{ m}$$

(c)

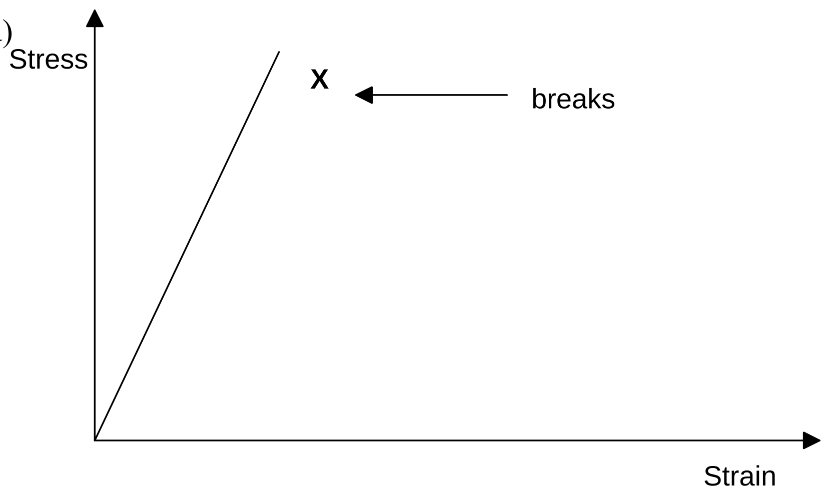
$$4.9 \times 10^8 = \frac{\text{Force}}{\pi (1.5 \times 10^{-3})^2}$$

$$\text{Force} = 3.46 \times 10^3 \text{ N}$$ (4)

Resolving vertically $2F \cos 45 = m \times 9.8$

$$\text{Mass required} = \frac{3.46 \times 10^3 \times 2 \cos 45}{9.8} = 500 \text{ kg}$$

(d)



(2)

8. (13 Marks)

(a)

$$P = I \times V$$
$$120 = I \times 240$$ (2)
$$I = 0.5\ A$$

(b) Power is lost in the long connecting cable. Voltage at the second transformer will be less that 12 V so the output will be considerably less than 240 volts. (2)

(c)

$$\frac{V_p}{V_s} = \frac{12}{240} = \frac{N_p}{N_s} = 1:20$$ (1)

(d) 10 V x turns ratio = 10 x 20 = 200 V AC (2)

(e) current is $\frac{8.3}{20} = 0.415\ A$ (2)

(f) Lost volts = 12 – 10 = 2 V (2 wires)

$$V = I \times R$$
$$2 = 8.3 \times R$$ (2)
$$R = 0.24\ \text{Ohms}$$

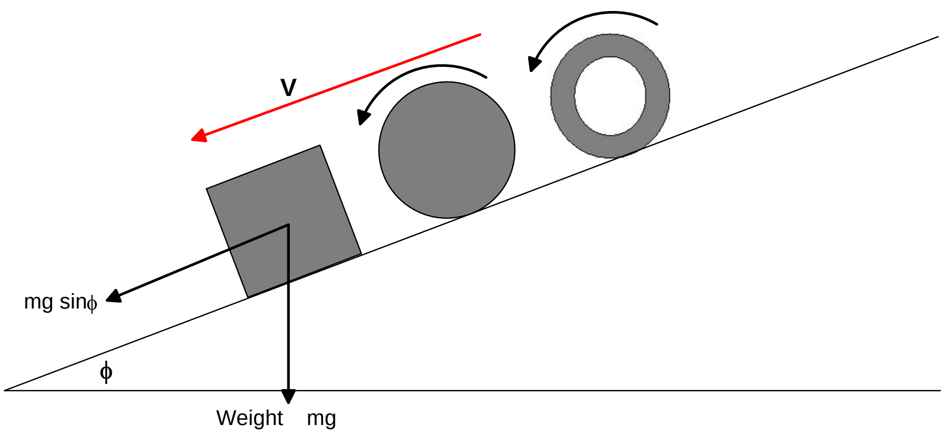
(g) B and C (2)

END OF SECTION B

Section C: Comprehension and Interpretation

Marks allotted: 40 marks out of 200 (20%)

Question 1 (22 marks)



(a) See diagram (2)

(b) The cylinders do not slip/ skid on the surface, even though smooth. (2)

Time of journey [s]	Acceleration [ms^{-2}]	Angle of slope [ϕ]	Sin ϕ
	0	0	0
1.88	1.13	10	0.17
1.33	2.26	20	0.34
1.09	3.37	30	0.50
0.96	4.34	40	0.64
0.89	5.05	50	0.76
0.83	5.81	60	0.866

(c) Fill in the acceleration column using the formula $s = ut + \frac{at^2}{2}$ (2)

(d) Force (down the slope) = mg sin ϕ (2)
show arrow as on diagram. (1)

(e)

$$mgh = mg2\sin\phi = \frac{v^2}{2}\left(m + \frac{I}{r^2}\right)$$ since vertical height change = 2sin ϕ

a is the linear acceleration down the slope

$v^2 = 0^2 + 2as$ $\quad$ $v^2 = 4a$ (since s = 2 m)

$$\frac{2mg2\sin\phi}{\left(m + \frac{I}{r^2}\right)} = 4a$$

$$\text{acceleration} = a = \frac{mg\sin\phi}{\left(m + \frac{I}{r^2}\right)}$$ (5)

(f) Therefore plot acceleration against sin ϕ and gradient is $\frac{mg}{\left(m + \frac{I}{r^2}\right)}$

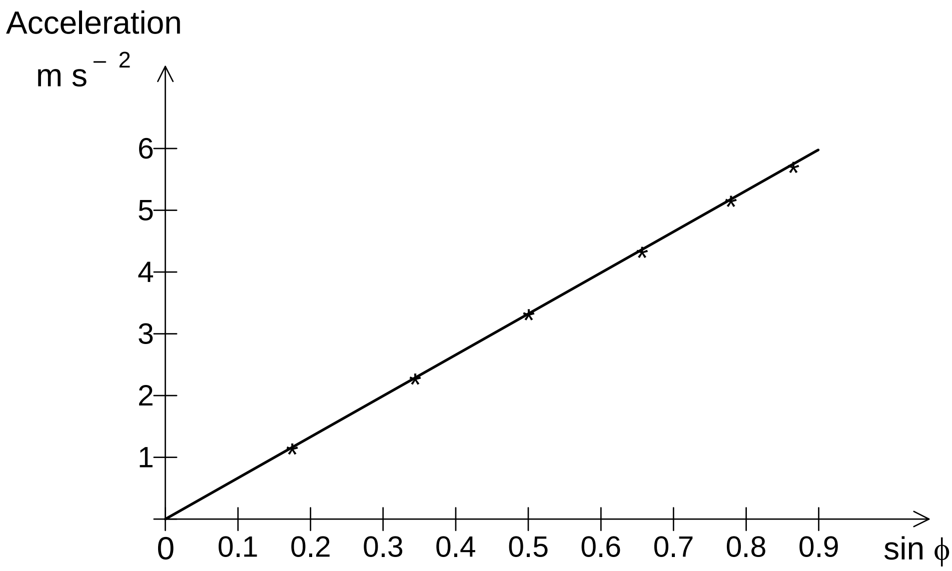
(graph 3)

$$\text{GRADIENT} = 6.6 = \frac{mg}{\left(m + \frac{I}{r^2}\right)} = \frac{2 x 10}{\left(2 + \frac{I}{0.25}\right)}$$

$$\left(2 + \frac{I}{0.25}\right)6.6 = 20$$ (3)

$$\frac{I}{0.25} = \frac{20}{6.6} - 2 = 1$$

I = 0.25 [units not important; kg m^2]



(g) The block would traveldown the slide in the shortest time. The reason is that there is no rotational energy. So all the potential energy will transfer into translational energy. (2)

Question 2 **(18 Marks)**

(a) Most [95 %] of all cars / trucks / m/bikes /4 wheel drives are petrol / diesel powered. (1)

(b)

$$\frac{100 \times 1000}{60 \times 60 \times 5} = 5.55 \text{ m s}^{-2}$$ (1)

(c) Battery size would have to be reduced thus making performance and range significantly less. (2)

(d) On slowing down the motion is used to rotate the coil in dynamo so using the motion usefully to produce electricity. This charges up the battery as well as slowing down the vehicle. (2)

(e) Extra energy is needed to recharge the Li-ion batteries. (1)

(f) Does not get hot, does not have to have huge torque acceleration provided by the battery and the motor. Principle of operation is different so electric motors can be 80 % efficient compared to internal combustion engines. (2)

(g)

$$\text{Gain in KE} = 0.5 \times 1500 \times \frac{(72 \times 1000)^2}{(60 \times 60)^2}$$ (2)

$$= 3.0 \times 10^5 \text{ J} \quad (300 \text{ KJ})$$

(h) Large batteries affect the weight and therefore the performance of the car. (1)

(i) 20 km ; 10 stop starts /km $= \frac{10 \text{ x} \left(3 \text{ x} 10^5\right)}{2} \text{ x} 20 + 80 \text{ x} 10^3 \text{ x } 80$

$= 3.0 \text{ x} 10^7 + 6.4 \text{ x} 10^6 = 3.6 \text{ x} 10^7 \text{ J}$ (4)

(j) Key idea is to reduce mass of the car and the distance it can be used for without recharging. Power and acceleration has to be compromised. (2)

END OF EXAM