SECTION A

1. C
   - When an object travels at relativistic speeds, length contraction occurs.
   - This *length contraction* is only in the direction of travel as seen from a stationary observer.
   - Other dimensions are not affected.
2. s = 0.134 m
3. • Cosmic rays from the Sun (charged particles) interact with Earth's magnetic field.
   - They spiral towards the poles where they interact with gases and transfer energy.
   - Gaseous atoms become excited and then re-emit the energy as photons when excited electrons return to the ground state.

4a)

Proton	+2/3	+2/3	-1/3
Neutron	+2/3	-1/3	-1/3

Charges must sum to +1 for proton and to zero for the neutron.

4b)

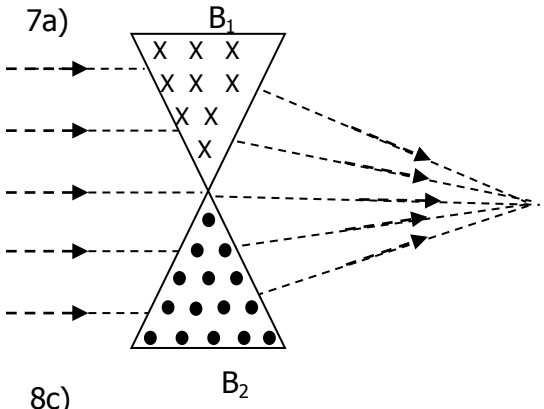
Proton	Hadron	Neutrino	Lepton
Muon	Hadron	Photon	Lepton

5. r = 1.14 mm

6.

Particle Accelerator	**Location**	**Primary Purpose**
Mass Spectrometer	Laboratories	Chemical Analysis
Large Hadron Collider	Cern	Particle collider. To re-create the conditions of the 'big bang' and analyse subatomic particles.
Australian Synchrotron	Melbourne	Produce specific intense synchrotron EMR for experiment.

7a)



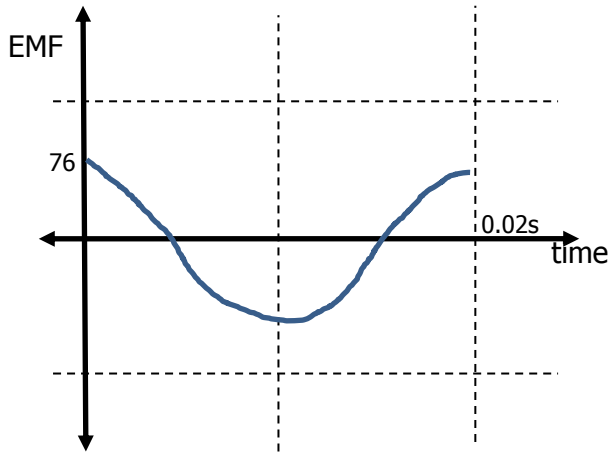
7b) $F = 2.4 \times 10^{-14}$ N

8a) AC; Slip ring commutator

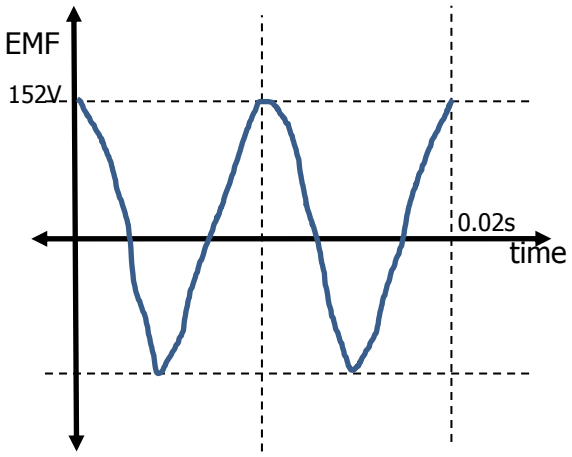
8b) 75.6 volt (average)

8c)

i) 3000 rpm



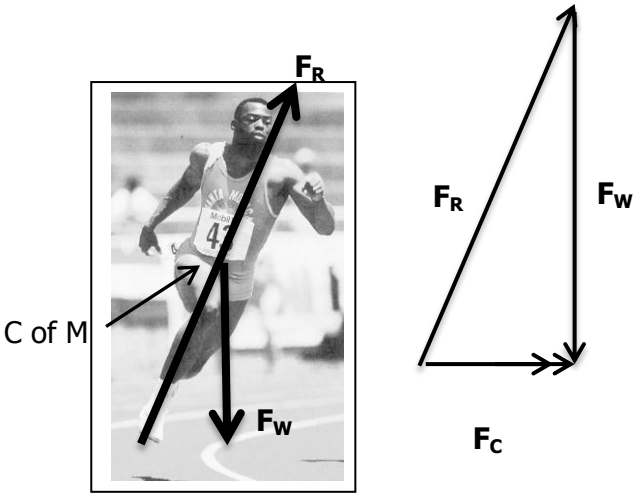
ii) 6000 rpm



9.
- AC can utilise transformers for voltage/current changes.
- High Voltage allows for low Current so as to maintain Power,
- while reducing $P_{loss} = I^2R$

10.
- Ring accelerates upwards but falls back immediately (it does not levitate).
- Magnetic field develops in coil inducing emf & current in the ring (according to Faraday's law).
- Induced current's magnetic field opposes coil's field & a force is experienced so that the ring rises.
- Because current is DC, the **B** field doesn't change & so the Force on the ring cannot be sustained.

11.



12.

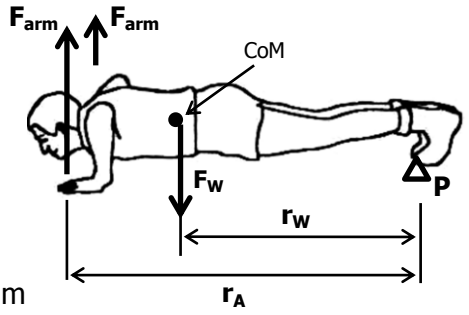
Assumptions:

Mass = 50 to 75 kg

CoM to Toe distance = 0.85 m to 1.05 m

Hand to Toe distance = 1.25 m to 1.50 m from hands

(see diagram)



Data ranges:

F_W: 490 N to 735 N; r_W: 0.85 m to 1.05 m; r_A: 1.25 m to 1.50 m

[Accept values in the range of: 165 N to 255 N]

13a) Altitude = 7.12×10^5 m OR 712 km

13b) No. "Geos" refers to the Earth, therefore it is not a Geostationary orbit.

SECTION B

1a) $f_{MAX} \Rightarrow \lambda_{MIN} \Rightarrow L_{MIN}$ Therefore the shortest tube.

1b) $0.3932\ m$

1c) No, the note would be different. For a closed tube, the fundamental frequency occupies ¼ λ. Blocking the bottom of the tube will double λ, therefore frequency will halve.

1d) $220\ Hz$

1e) "End correction" will have a larger effect as the diameter of the tube increases. λ will increase slightly, meaning the pitch (i.e. frequency) will decrease slightly.

1f) The waves reflect at ends & cause interference pattern. Producing nodes & antinodes due to destr & constr interference respectively. St waves need periodic waves of same frequency, amplitude & velocity.

2a) Visible light. 2b) $E = 2.176 \times 10^{-18}$ J 2c) $\lambda = 9.72 \times 10^{-8}$ m OR 97.1 nm 2d) 6 lines

2e) No photons will be absorbed. For absorption to occur, the energy of the photon must be exactly equal to the value of one of the energy levels.

2f) Line absorption spectrum 2g) Fraunhofer lines

2h) Fraunhofer lines include absorption spectra of elements present in the atmosphere of the Sun.

2i) No. Incandescent globes produces a continuous spectrum.

3a) E = 2.38 x 10^{-16} J 3b) $v = 2.286 \times 10^{7}\ ms^{-1}$

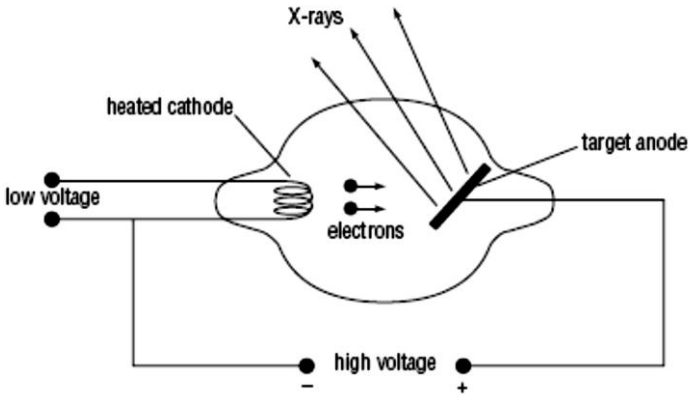
3c) No. Speed of e^- < 0.1*c*, at this speed the effects of *mass increase* would be minimal.

3d) #photons per second = 6.30 x 10^{19}

3e) The wavelengths of the electrons would be of a similar magnitude to that of the X-rays.

3f)

- A high voltage accelerates electrons which then strike a metal target anode.
- The high speed electrons are decelerated upon striking the target and their kinetic energy is converted into high energy EMR.



4a) E = 1.06 x 10^5 V/m 4b) v = 1.11 x 10^8 m/s 4c) r = 2.10 x 10^{-3} m 4d) B-field is out of the page.

4e) mass of the unknown element = 14.0 u The element is most likely to be Nitrogen.

5a) 5cm: F= 1.125 x 10^{-3} N 3 cm: F = zero. Because the current is parallel to the magnetic field.

5b) Torque is a vector, so student needs to know directions of the current & magnetic field to ascertain whether torque is positive or negative.

5c) Horizontal position. Although both positions have same magnitude of force, $r_\perp$ is max when coil is horizontal but $r_\perp$ = 0 when coil is in the vertical position so there is zero torque in the vertical position.

5d) $\tau = 3.375 \times 10^{-5}\ Nm$

5e) [Any 4]; Increase **B** / Increase I, either directly from the power pack OR use thicker windings in the coil / Increase number of turns N / Increase the Area of the coil / Include an extra coil / Use magnets with curved faces / Insert a Ferromagnetic core

5f) Swap "power pack" for a "load" (eg light bulb). Rotate coil to input Mechanical Energy for conversion to Electrical Energy.

5g) DC. The commutator given is a single split-ring type. AC requires 2 slip rings.

6a) u_X=38.97m/s; U_Y=22.5m/s 6b) 7.40m 6c) v_Y =19.01m/s 6d) t =4.235s 6e) s_x =165m 6f) s_y= 25.8m

7a) T = 4.90 x 10^4 N; 7b) R = 7.65 x 10^4 N at 33.7^0 to the vertical

SECTION C

1a) Axes Labels / Scales / Plotting / Error Bars / LOBF

1b) 3.975 x10^4 km/s ± 15% MUST show clearly on graph. AcceptRange: 3.38 x 10^4km/s to 4.57 x 10^4 km/s

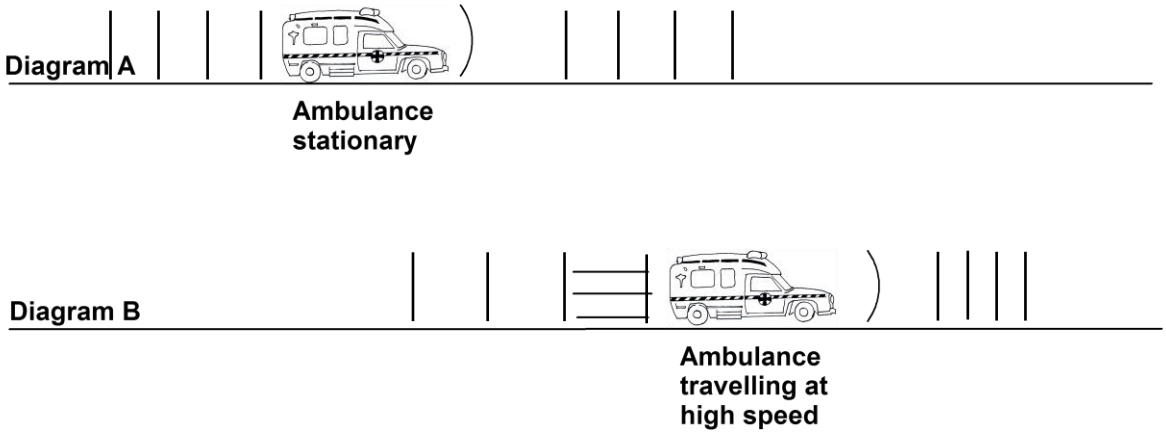
1c) Using gradient triangle: $slope$ = 5.357 x 10^{-5} kms^{-1} ly^{-1} H_0 =174.6 $km.s^{-1}$ Mpc^{-1}

1d) v_g = 6.48 x 10^6 ms^{-1}

1e) t = 5.00 x 10^9 years (5 Billion years)

2a) frequency

2b)



2c) No. The actual pitch remains the same, it is only the perceived pitch that alters due to the relative motion between the objects.

2d) Graph. Should be horizontal lines for each of the 3 sections. Frequency should be highest as the vehicle approaches, then drop as the vehicle passes. Finally, the frequency should fall immediately after the vehicle travels onward.

2e) $\lambda = vxT$

2f) distance = u x T u = velocity of ambulance
T = period (i.e. the time between the 1st and 2nd wavefronts

2g) (i) $d = vT - uT$

(ii) $d = vT + uT$

2h)

- The apparent change in wavelength of light emitted by an object moving away from the Earth.
- The wavelengths shift towards the red end of the spectrum.

2i)

- The apparent change in wavelength of light emitted by an object moving towards the Earth.
- The wavelengths shift towards the blue end of the spectrum.

2j) Yes. As the observer approaches the siren, he will hear more waves per second than if he were stationary. Therefore he would observe a higher frequency. So he must experience the Doppler Effect.

<u>Spare Question:</u>

a) B-field is into the page.

b) $v = 6.01 \times 10^7 \text{ ms}^{-1}$