SECTION A

1a) Infrared 1b) 1.6 x 10^{16} photons

2. Supports the wave model. Pattern caused by diffraction which is a wave property. Constructive / Destructive interference is a wave property.

3. λ(AM) = 300m λ(FM) = 3m. The larger the λ, the greater the diffraction. So AM waves are diffracted more & so will be detected in the tunnel, while FM waves more directional & will likely be reflected from the surroundings as if the (hole) tunnel wasn't there.

4. [old syllabus]

5. 15.6 m/s (56 km/h

6a) diagram 6b) 1.87 x 10^{3} N

7. 78.1 m

8. 2.4 x 10^{20} N (2 sf for estimations) towards the Sun. Tidal changes would be noticed during such an eclipse.

9. 0.35 V

10. 1.49 Nm. Purpose – to reverse the current direction in the inner circuit in order to maintain the same direction of rotation.

11a) 18 turns

11b) Large eddy currents are induced in the transformer core. These dissipate heat (P = I^2 R_ which can cause damage (and fires etc). Thin laminated sheets greatly reduces the effect of the eddy currents by preventing them from combining into a larger resultant current.

12. Vector diagrams (minimum of 3) should show the Reaction force increasing and moving closer to the ladder as the man climbs the ladder. The vertical component increases but the horizontal component remains the same.

13. Can maintain balance (equilibrium) by shifting the CoM so that it lies within the support base at all times. This is done by arm and leg movements within the dance itself. The CoM produces a torque if it lies outside the base. Unless this torque is counter-balanced, the dancer will topple over. The arm/leg movements enables the counter-torques to prevent this from happening.

14. [old syllabus] 15. [old syllabus]

SECTION B

1a) positive 1b) 4.1 x 10^{5} m/s 1c) 1.4 x 10^{-13} N 1d) 8.7 cm

1e) Determines the identity of an unknown ion by separating the various isotopic masses. Measures the relative abundance of isotopes (different mass = different radius). Can also measure the masses and relative concentrations of atoms / molecules.

2a) 6 (must be shown on the diagram 2b) 771 nm 2c) 1.91 x 10^{6} m/s

2d) No wavelengths will have a reduced intensity. [must show one calculation of a wavelength]. Protons can only be absorbed completely and only from the ground state. Photons that are absorbed are scattered and their intensity in the absorption spectrum is reduced – appearing as dark lines. All 3 possible lines produce UV photons and not visible light photons.

2e) There is a large PD across the electrodes. Electrons are fired from the cathode to the anode. Electrons impact on Mercury atoms, which become excited and return to the ground state emitting UV light. The UV light hits the phosphor coating inside the tube; these atoms excite and then emit visible light photons when they de-excite via multiple transitions. This is essentially a Fluorescent process where UV photons cause the emission of visible light photons.

3a) B 3b) 50 Hz 3c) 3.50×10^{-3} Wb

3d) Advantages: stronger **B** field possible $\Rightarrow$ greater EMF; Don't "wear-out" like permanent magnets. Disadvantages: "cold start" not possible without an external power supply (eg batteries) to excite the stator windings.

3e) Large eddy currents produce heat ($P_{loss} = I^2R$), this can cause damage and effect efficiency.

3f) Higher voltage lowers the current for the same power transmitted. Power loss in the transmission lines due to I^2R loss is reduced.

3g) AC provides a $\Delta\Phi$ which is needed for use in the transformers which don't work with DC. If DC were used, then the advantages of reducing power loss in the lines would not be possible.

4a) 3.73×10^4 s OR 10.4 hours 4b) 2.43×10^6 m 4c) 0.682 N kg^{-1} (must use correct units).

4d) Need at least 3 satellites for triangulation and thus global location. For whole earth coverage there are many orbits needed, and so they cannot be in geostationary orbits.

5a) 3.64×10^3 N 5b) 3.56×10^3 N 5c) 105 N (very small compared to R_X).

5d) Maintain straight back, bend knees, and keep load as close as possible. This will produce minimal torque since the lever arm (distance to the feet) is minimised. The reduced torque requires less counter torque from the back muscles and so there is less strain and less risk of damage to surrounding tissues.

6. [old syllabus]

7a) At resonant position there would be a marked increase in the loudness of the sound. This suggests constructive interference of the sound and its reflection.

7b) Must complete a 1/f row (with the label of '10^{-3} s') in given table. $L = \frac{v}{4f}$ so a graph of L vs f^{-1} should produce a straight line with a gradient of ¼v.

7c) Vertical axis = length (m); Horizontal axis = f^{-1} ($x10^{-3}$ s). Should get 2 straight lines through the origin.

7d) experimental error / need of more repetitions to increase the accuracy.

7e) **From graph (must show),** gradient $\simeq$ 72. Since gradient = ¼ v, v = 4 x gradient $\simeq$ 288 m/s

7f) Graph 1: Straight line through the origin.
Graph 2: steeper gradient but still through the origin.
Graph 3: Straight line with same gradient as graph 1, but with a positive y-intercept.

SECTION C

Question 1

1. X-rays wavelength is similar to the interatomic spacing in crystal structures. Therefore diffraction is optimised.
2. The narrow beam of x-rays has undergone diffraction.
3. Bragg wanted to arrange the dots & pinholes on a large scale to simulate a crystal structure. He then used correspondingly long wavelength visible light to simulate x-rays. These wavelengths are

much
safer to work with than x-rays.
4. Spacing of the pinholes should be of the same magnitude as the wavelength of visible light. 5×10^{-7}m.
5. X-ray diffraction photos show exposed dark interference lines on a light background. X-ray shadow
photos show bone as white unexposed shadows on a dark exposed background.
6. Crystal structures have a regular repeating pattern that will consistently diffract x-rays. Wood doesn't
have a regular arrangement of atoms and therefore will not diffract consistently.
7. "Diffraction patterns constitute evidence of periodically repeating arrangements of atoms in crystals.
The symmetry of the diffraction patterns correspond to the symmetry of the atomic packing".
8. No. The samples used in x-ray diffraction are very thin (a few microns) therefore most wavelengths
would be able to penetrate the sample.

Question 2

1. The ΔB field induces a current in metal saucepans. This causes heat in the pot due to its resistance

($P_{loss}t = I^2 Rt$ = Heat). User's hand is not metallic & therefore no current is induced.
2. Resistance of metal pan is far lower than the user. So, current will not flow through the hand.
3. Copper has a very low resistance & so the current induced would be excessive. Glass is an insulator.

4a) 31.6 A 4b) 8.33 A

5. No. Need a ΔΦ as provided by AC. DC cannot provide this except for a very short period when the B
field is first established.
6. High resistance leads to a very small current and thus a greatly reduced dissipation of heat since $P_{loss} = I^2R$.