2020 Physics Trial Examination Solutions © itute 2020

SECTION A

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
C	B	A	C	C	B	D	D	C	B	A	D	D	C	C	B	A	C	B	D

SECTION B

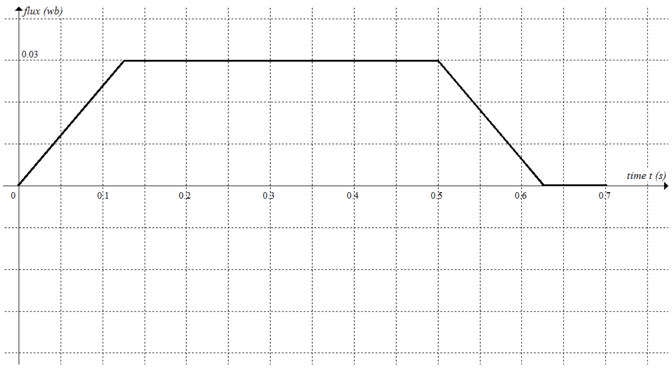
Question 1

a. $|\xi| = \left| -n \times \frac{\Delta\phi}{\Delta t} \right| = 2 \times 1.5 \times 0.10 = 0.30$ v

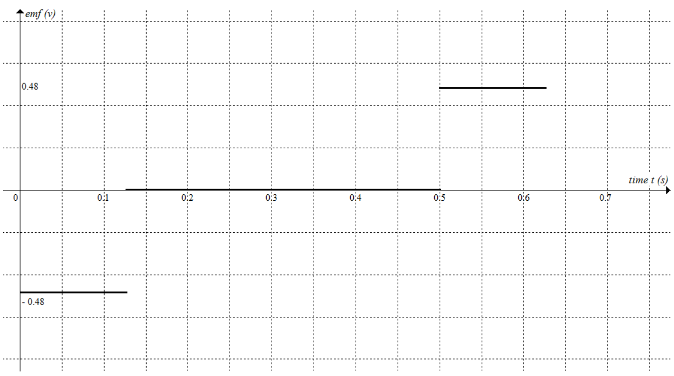
b. To counter the increase in upward magnetic flux according to Lenz's law, an induced current in the coil flowing from B to A is generated. Hence current will flow from A to B in an external circuit connected to terminals A and B. .: A is at higher potential.

c. $\phi = BA = 0.30 \times 0.10 = 0.030$ wb

d.



e.



Question 2

a. At any position P on a solid curve (pressure anti-nodal line) the path difference (difference in distances from the two loudspeakers) is $n \times$ wavelength of the sources where $n = 0, 1, 2, \ldots$.

Since the two sources are in phase, superposition of compressions (or rarefactions) from the two sources arriving position P at the same time occurs, giving rise to a stronger compression (or rarefaction) at P, i.e. constructive interference occurs at P.

b. $\Delta x = \frac{\lambda L}{d}$, $0.9 = \frac{\lambda \times 5.0}{2.0}$, $\lambda = 0.36$, $f = \frac{v}{\lambda} \approx 9.6 \times 10^2$ Hz

c. $QX - PX = \frac{3}{2}\lambda = \frac{3}{2} \times 0.36 = 0.54$ m

d. Distance between 2 adjacent pressure anti-nodes $= \frac{\lambda}{2} = 0.18$ m.

P and Q are 2.0 m apart. .: there are 12 pressure anti-nodes from P to Q.

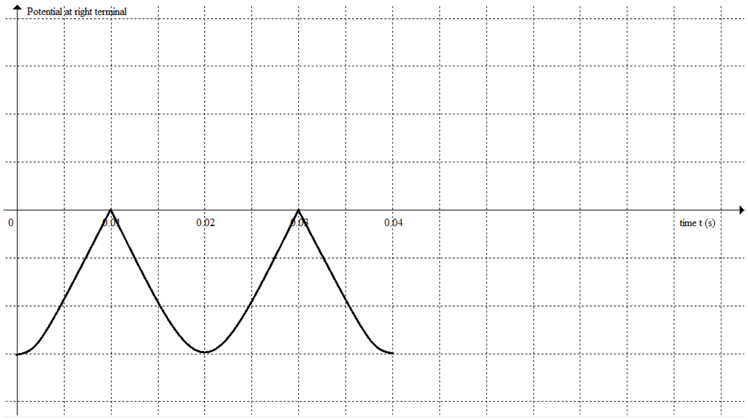
Question 3

a. Anticlockwise

b. $F = nIlB = 25 \times 2.0 \times 0.020 \times 0.50 = 0.50$ N

c. $T = \frac{1}{f} = \frac{1}{25} = 0.040$ s.

The left terminal has a higher potential and it is earthed, 0 v, .: potential at the right terminal is lower than 0 v.



Question 4

a. 240 v

b. Machine resistance $= \frac{V^2}{P} = \frac{240^2}{2.0 \times 10^3} = 28.8\ \Omega$

c. $I = \frac{V}{R} = \frac{240}{1.9 + 28.8} \approx 7.82$ A, $P = I^2 R = 7.82^2 \times 28.8 \approx 1.76 \times 10^3$ w ≈ 1.8 kw

$V = IR = 7.82 \times 28.8 \approx 225$ v

d. Pump resistance $= \frac{V^2}{P} = \frac{240^2}{0.75 \times 10^3} = 76.8\ \Omega$

Total resistance of whole circuit (extension cords, machine, pump) $= 1.9 + \frac{1}{\frac{1}{28.8} + \frac{1}{1.9+76.8}} \approx 23.0\ \Omega$

Current in the first extension cord $= \frac{V}{R} = \frac{240}{23.0} \approx 10.43$ A

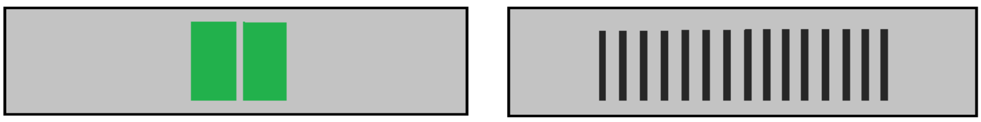
Voltage drop across machine $= 240 - 10.43 \times 1.9 \approx 220.2$ v, within 220 – 240 v, machine operates properly.

e. Current in the second extension cord $= \frac{220.2}{1.9 + 76.8} \approx 2.8$ A

Voltage drop across pump $= 2.8 \times 76.8 \approx 215$ v, lower than 220 v, pump does not operate efficiently.

Question 5

a. Student's result: Two green patches of light on the screen. Young's result: Bright and dark fringes.



Student's result   Young's result

b. The slits on the student's prepared double-slit were too wide (1.0 μm) in comparison with the wavelength of green laser light (530 nm = 0.53 μm). Light wavelength must be greater than the slit width for significant diffraction to occur. Hence there was very little diffraction of light passing through each slit, and no interference of the lights from the two slits was possible because the slits were too far apart. In Young's experiment, the slit width was much smaller than the light wavelength, and the slits were close. Diffraction of light through each slit occurred and the lights interfered to produce the pattern.

Question 6

a. $a = 1.8\ \text{m s}^{-2}$, weight $= mg = 500 \times 1.8 = 900\,\text{N}$

b. $g = \left(\dfrac{2R+R}{1.5R+R}\right)^2 \times 1.8 \approx 2.6\ \text{N kg}^{-1}$

c. $\dfrac{v_B}{v_A} = \sqrt{\dfrac{r_A}{r_B}} = \sqrt{2} \approx 1.4$

d. $\dfrac{T_B}{T_A} = \sqrt{\left(\dfrac{r_B}{r_A}\right)^3} = \sqrt{\left(\dfrac{1}{2}\right)^3} \approx 0.35$

e. Increase in gravitational potential energy $\approx 500 \times 1.8 \times 100 = 9.0 \times 10^4\,\text{J}$

Question 7

a. Sideway friction $= \dfrac{mv^2}{r} = \dfrac{1200 \times 7.5^2}{19.8} \approx 3410\,\text{N}$

b. $\tan\theta \approx \dfrac{3410}{1200 \times 9.8}$, $\theta \approx 16.2°$

c. $F_f \cos 16.2° + 3410 = \dfrac{1200 \times 8.5^2}{19.8}$, $F_f \approx 1.0 \times 10^3\,\text{N}$

Question 8

a. Spring constant $k = \dfrac{120}{0.10} = 1200\,\text{N m}^{-1}$

b. $E = \dfrac{1}{2} \times 60 \times 0.050 = 1.5\,\text{J}$

c. $E = \dfrac{1}{2} \times 120 \times 0.10 - 1.5 = 4.5\,\text{J}$

d. $\dfrac{1}{2} \times 0.20 \times v^2 + 0.20 \times 9.8 \times 0.10 \sin 30° = \dfrac{1}{2} \times 120 \times 0.10$, $v \approx 7.68 \approx 7.7\,\text{m s}^{-1}$

e. Horizontal component of velocity $\approx 7.68 \cos 30° \approx 6.65\,\text{m s}^{-1}$, $E_k \approx \dfrac{1}{2} \times 0.20 \times 6.65^2 \approx 4.4\,\text{J}$

f. Vertical component, mouth of barrel to the top: $u = {}^+7.62$, $a = {}^-9.8$, $v = 0$, $s = \dfrac{7.62^2 - 0}{2 \times 9.8} \approx {}^+2.96\,\text{m}$, $t \approx 0.778\,\text{s}$

Vertical component, top to ground: $s = {}^-2.96 + {}^-0.20 \sin 30° = {}^-3.06$, $u = 0$, $a = {}^-9.8$, $t = \sqrt{\dfrac{{}^-3.06}{\frac{1}{2} \times {}^-9.8}} \approx 0.790\,\text{s}$

Horizontal component: $s = {}^+6.65 \times (0.778 + 0.790) \approx {}^+10.4$, horizontal distance $\approx 10\,\text{m}$

Question 9

Let the two events be spaceship leaving Mars and spaceship arriving Earth.

Spaceship observer: The 2 events occur at the same point (outside the spaceship window), proper time t_o of travel is measured. The distance (Mars-Earth) travels past the spaceship observer, contracted length L is measured.

Speed calculated by spaceship observer $= \dfrac{L}{t_o} = \dfrac{L_o}{\gamma t_o}$

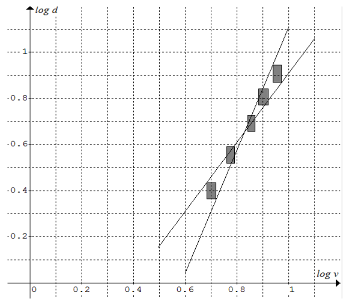
Earth observer: The two events occur at different places, dilated time t of travel is measured. The distance (Mars-Earth) is at rest relative to the Earth observer, proper length L_o is measured.

Speed calculated by Earth observer $= \dfrac{L_o}{t} = \dfrac{L_o}{\gamma t_o}$

Question 10

a. Type of floor: Different floor surfaces exert different forces of friction on the sliding object. Same floor with uniform surface must be used throughout the investigation to find the relationship between stopping distance of an object sliding on the floor and its initial speed.

b.



Min. gradient $\approx \dfrac{1.05-0.17}{1.1-0.5} \approx 1.5$

Max. gradient $\approx \dfrac{1.10-0.05}{1.0-0.6} \approx 2.6$

$n \approx \dfrac{1.5+2.6}{2} \approx 2.1 \pm 0.6$

c. $0.1 \times mg \times d = \dfrac{1}{2}mv^2$, $d = \dfrac{5}{g}v^2$

d. Experimental: $d \propto v^{2.1\pm0.6}$; theoretical: $d \propto v^2$. 2 is within 2.1 ± 0.6.
Conclusion: the experimental result verifies the theoretical result within the margin of error.

e. $d = \dfrac{5}{g}v^2$, mass m does not appear in the equation, the no. of passengers has no effects on the stopping distance.

Question 11

a. $27\text{ MeV} = 27 \times 10^6 \times 1.6 \times 10^{-19} \approx 4.3 \times 10^{-12}\text{ J}$

b. $\Delta m c^2 \approx 4.3 \times 10^{-12}$, $\Delta m \approx 4.8 \times 10^{-29}\text{ kg}$

Question 12

a. Photons in light have a range of energy (frequency/wavelength). Photons with certain energies will be absorbed by the hydrogen atoms causing the atoms to transit to the excited states. The dark lines in the spectrum indicate missing photons in the spectrum caused by absorption.

b. $E = \dfrac{hc}{\lambda} = \dfrac{(6.63\times10^{-34})(3.0\times10^{8})}{658\times10^{-9}} \approx 3.0\times10^{-19}\text{ J}$

c. $n = 2$ to $n = 5$

Question 13

a. Violet light frequency $= \dfrac{c}{\lambda} \approx \dfrac{3.0\times10^{8}}{400\times10^{-9}} = 0.75\times10^{15}\text{ Hz}$

It is less than the threshold frequency of 1.04×10^{15} Hz. Visible light cannot be used on zinc metal to demonstrate the photoelectric effect because no photoelectrons will be emitted.

b. Increase the intensity of light of the same frequency.

c. Increase the frequency of light.

Work function of zinc $W = (6.63\times10^{-34})(1.04\times10^{15}) \approx 6.9\times10^{-19}$ J,

$E_{\text{K,max}} = \dfrac{hc}{\lambda} - W = \dfrac{(6.63\times10^{-34})(3.0\times10^{8})}{270\times10^{-9}} - 6.9\times10^{-19} \approx 4.7\times10^{-20}\text{ J}$

e. For certain light intensity (a fixed number of photons) only a fixed number of electrons emitted per second. The maximum current is the fixed number of electrons emitted per second when the accelerating voltage increases.

f. The emitted electrons have a range of kinetic energy up to $E_{\text{K,max}}$. When the retarding voltage increases in magnitude, more emitted electrons will be stopped from reaching the collecting electrode and hence less current will be registered.

Question 14

a. Electron wavelength $\approx 0.154\times10^{-9}$ m, $v = \dfrac{h}{m\lambda} \approx \dfrac{6.63\times10^{-34}}{(9.1\times10^{-31})(0.154\times10^{-9})} \approx 4.7\times10^{6}\text{ m s}^{-1}$

b. $qV = E_{\text{K}}$, $V = \dfrac{\frac{1}{2}mv^2}{q} = \dfrac{\frac{1}{2}(9.1\times10^{-31})(4.7\times10^{6})^2}{1.6\times10^{-19}} \approx 63\text{ v}$

