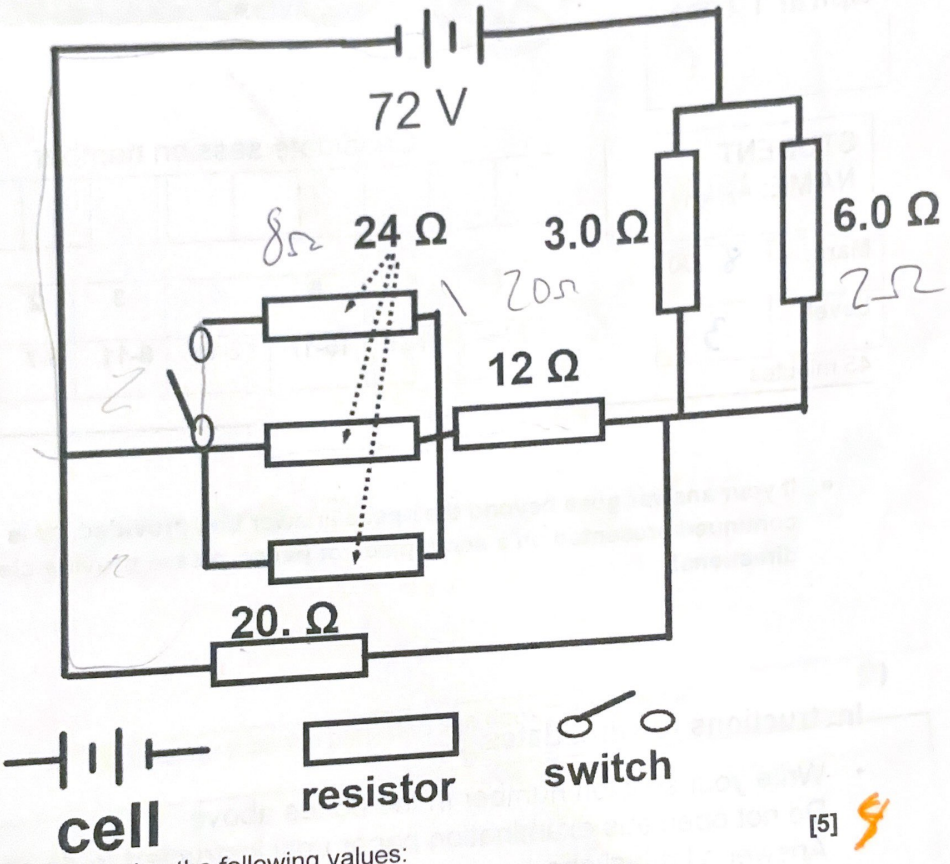
Spiral 1 Test

1. This question is about electricity.

The circuit switch on the circuit is closed.



[5]

a. Determine the following values:

Overall resistance of the circuit	12Ω
Overall current for the circuit	6A
Potential difference across the 20 Ω resistor	60V
Potential difference across the 12 Ω resistor	36V
Current through the bottom-most 24 Ω resistor	1A

b. If the switch is opened, will the current through the 6 ohm resistor increase, decrease, or remain the same? Explain without using calculations. [2]

Remains the same as the resistor is approached first before the switch, according to current flow, it will not affect the current in the resistor. It will remain the same.

It increases because current will no longer split at a parallel due to it being open

c. The 3.0 Ω resistor has a length of 1.20 cm and a volume of 3.00×10^{-7} m^3. What is the resistivity of the resistor's material? [1]

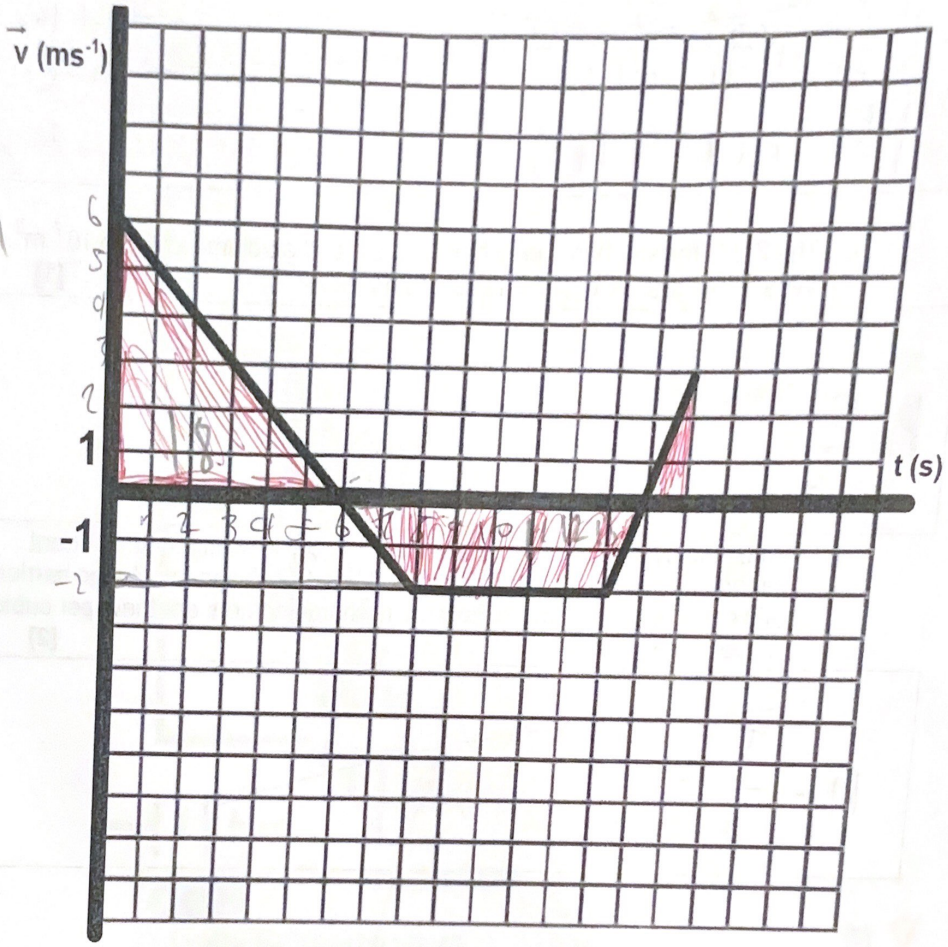
$\rho = \frac{RA}{L} = 0.00625\ \Omega m$

d. When the overall potential difference of the cell is changed, the current through the same 3.0 Ω resistor as part b is 1.00 A and the charge carrier drift speed is 0.075 mms^{-1}. How many charge carriers are there per cubic metre of the material? [2]

$n = \frac{I}{eAv_d} = 3.33 \times 10^{27}$

2. This question is about mechanics.

a. The graph represents the motion of an object in one dimension. One square represents exactly one metre in the y axis and one second in the x axis.



i. What is the object's displacement during the first 10 seconds?

[1] 0

add areas together = 14 meters 6.5m

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Spiral 1 Test

Janssen

ii. What is the object's acceleration during the first 6.0 seconds? [1]

$-1\ m/s^2$ 1

b. Your friend has the answers to this test and rides their bike past you laughing maniacally at a speed of 13.5 ms^{-1}. You immediately accelerate at a constant rate of 4.5 ms^{-2} until you catch them. How far do you both travel in that time? [2] 0

$v^2 = u^2 + 2as$

$= \sqrt{2(4.5)(5)}$ $13.5^2 = 13.5^2 + 2(0)(5)$ $\frac{1}{2}(13.5)(5) = 33.75$

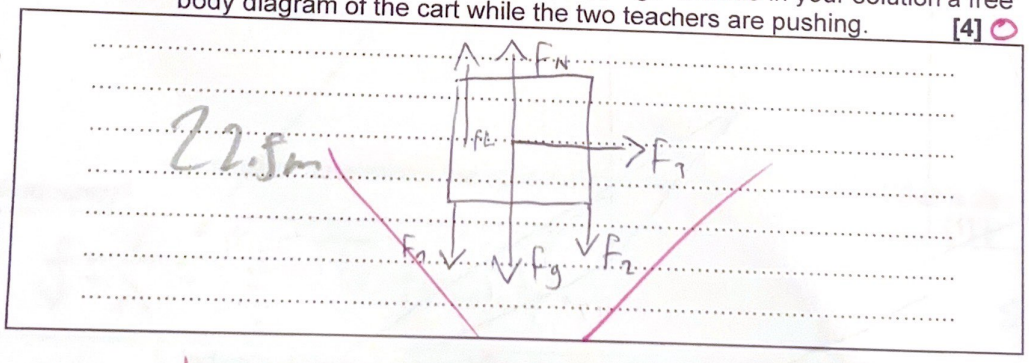
We travel for 67.5 meters. 81m

1	13.5	0
2	27	4.5
3	40.5	27
4	54	45
5	67.5	67.5

$t = 5$
$u_1 = 13.5$
$u_2 = 0$
$v_1 = 13.5$
$v_2 = ?$
$a_1 = ?$
$a_2 = 4.5$

$s = \frac{(13.5+13.5)5}{2} = 67.5$

c. Ms. Janssen and Mr. Paterson wish to push a 15 kg science cart loaded with 25 kg of textbooks down a hallway. Ms. Janssen pushes with 120. N of force [N] while Mr. Paterson pushes with 90. N [E], and they push together for 3.0 s. There is a resistive force acting in the opposite direction that the cart is moving, equal to 50.0 N. Once they stop pushing, how far will the car travel before stopping? Include in your solution a free body diagram of the cart while the two teachers are pushing. [4] 0



b) $vt = \frac{1}{2}at^2$

$13.5t = \frac{1}{2}4.5t^2$

$t = 6$

c)

5

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d. An ant follows a trail of crumbs 0.75 m [N38°E], then 1.20 m [S], then 0.85 m [E27°S]. What is her displacement at the end of the journey?
[4]

2.

$x_1 + x_2 + x_3$

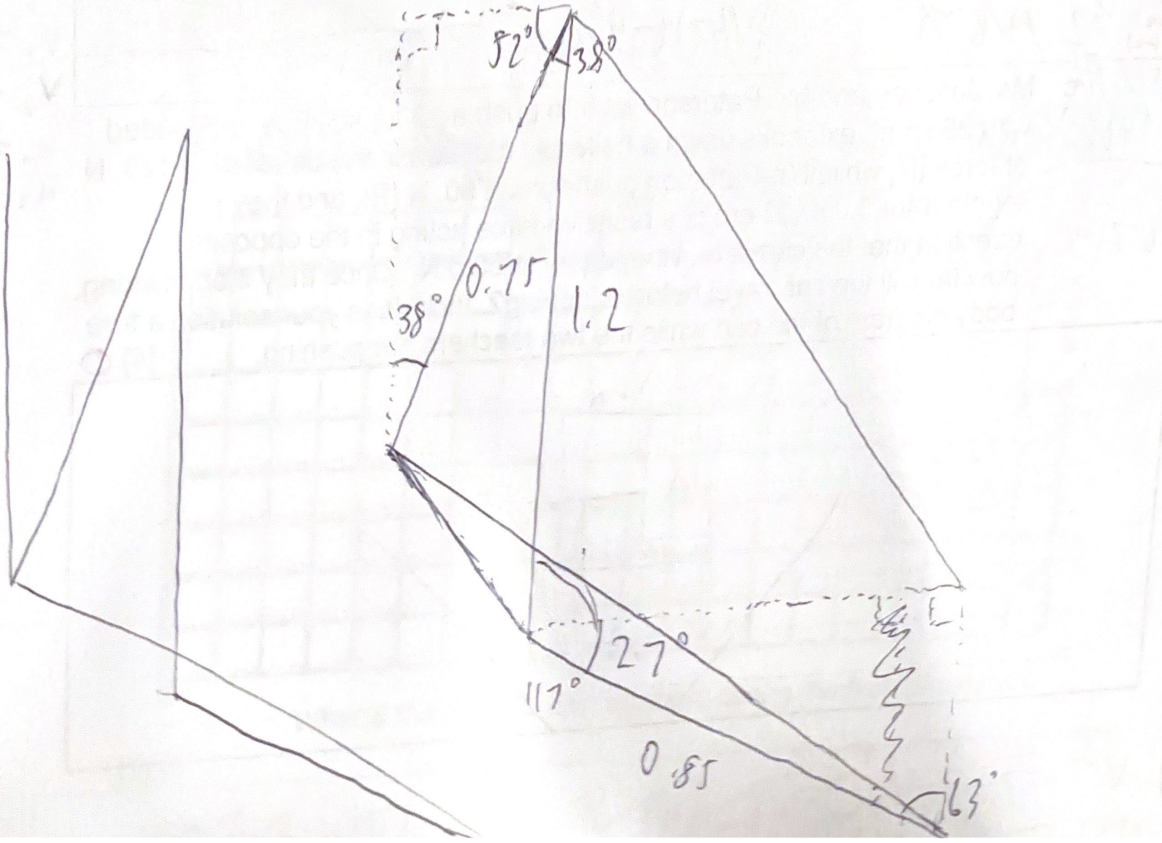
$y_1 + y_2 + y_3$

$0.75 \sin 38 + 0 + 0.85 \cos 27$

$0.75 \cos 38 + -1.2 + -0.85 \sin 27$

$s = \sqrt{x^2 + y^2} = \sqrt{1.22^2 + -1^2}$

$= 1.577\text{m}$



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Spiral 1 Test

Janssen

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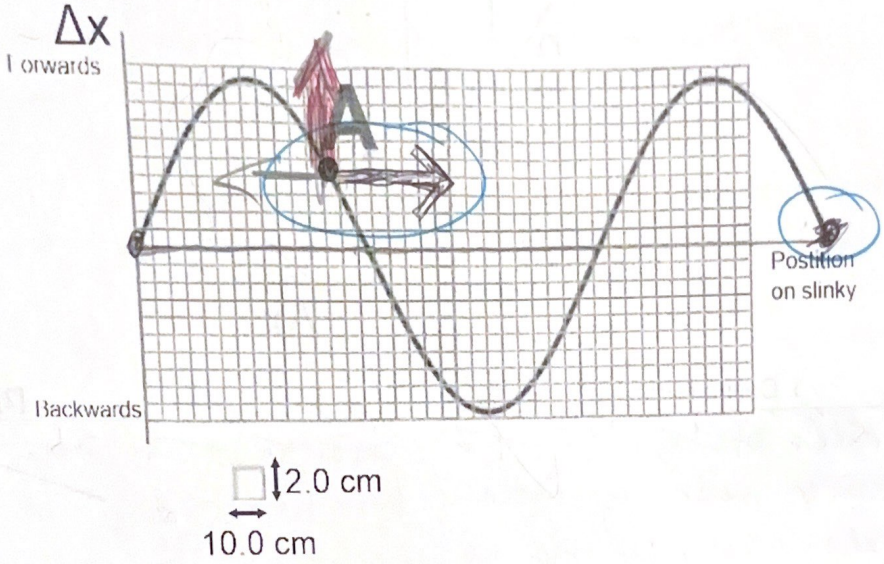
3. This question is about waves.

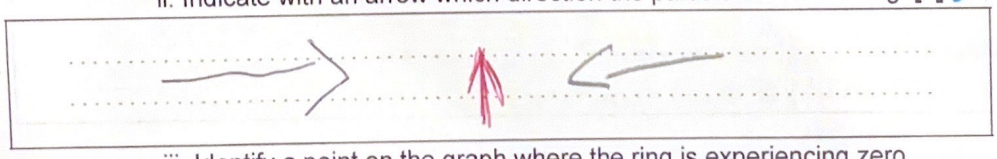
a. The graph shows the displacement of the rings of a slinky vs. the position along the slinky, which is undergoing a longitudinal wave.



i. A student determines the speed of the wave to be 1.0 ms^{-1}. What is its frequency? [1] 1

$f = \frac{v}{\lambda} = \frac{1}{2.9}$ The frequency is 0.3448 Hz. SD

ii. Indicate with an arrow which direction the particle at A is moving. [1] 0



iii. Identify a point on the graph where the ring is experiencing zero acceleration. [1] 1

~~End~~ of wave

start

Start of wave

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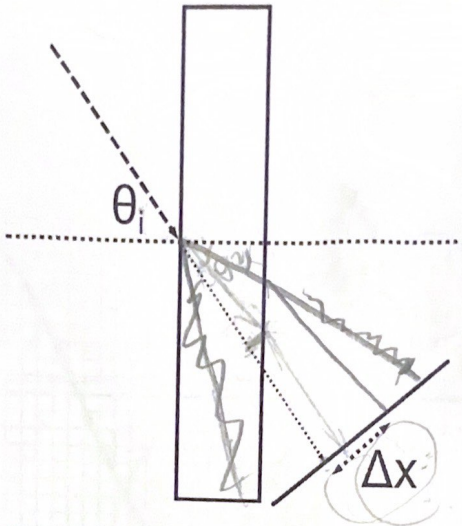
b. A light ray is 45° incident on a 2.0 cm thick block of plastic with a refractive index of 1.75. After the ray undergoes refraction twice (from air to plastic, then from plastic to air), it strikes a detector on the other side.



i. Define refractive index. [2]

index of light travelling through a medium number describing how fast light travels through a median indicating how much light is refracted through material

ii. How far from the projected line does the ray strike? [3]

$n_1 \sin\theta = n_2 \sin\theta$

$1 \sin 45° = 1.75 \sin\theta$

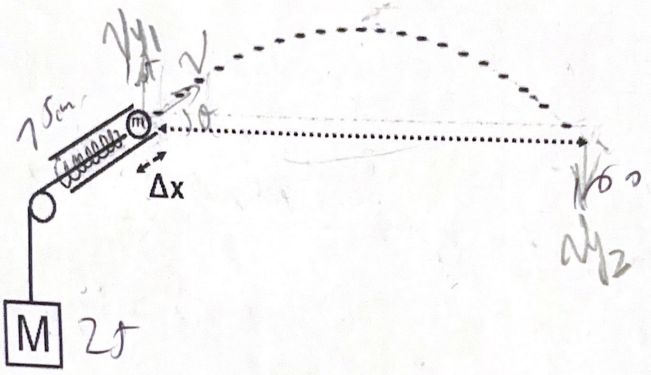
$\theta = 24°$

----------END----------

Spiral 2a Test

Paterson/Janssen

1. A projectile launcher uses a spring mechanism to launch small masses. As shown in the diagram, a large mass is suspended over a frictionless pulley from the spring to compress it a distance Δx, and to launch the small mass m the large mass M is released.



a. Demonstrate that the distance travelled by the small mass after launch, to land at the same height as the launch point, is given by the equation

$$d = \frac{M}{m}\Delta x \sin(2\theta)$$

[4]

$E = \frac{1}{2}kx^2$

$E = \frac{1}{2}mv^2$

$v_x = v\cos\theta$

$v_y = v\sin\theta$

$d = v_x t$

$U_s = \frac{1}{2}kx^2$ $\quad \frac{1}{2}kx^2 = mgh$

$U_g = mgh$ $\quad h = \frac{kx^2}{2mg}$

$d = u\cos(\theta)\,t$

$u = \sqrt{\frac{2kx^2}{m}}$

$h = \frac{1}{2}gt^2$

$t = \sqrt{\frac{2h}{g}}$

$d = \sqrt{\frac{2kx^2}{m}} \cdot \cos\theta \sqrt{\frac{2\frac{kx^2}{2mg}}{g}}$

$= \frac{x\sin\theta}{g}\sqrt{\frac{kx^2}{m}}$

$= \frac{2x\sin\theta\cos\theta}{g}\sqrt{\frac{kx^2}{m}}$

$= \frac{2x\sin\theta\cos\theta \cdot x}{g}\sqrt{\frac{k}{m}}$

$= \frac{x\sin(2\theta)\cdot x}{g}\sqrt{\frac{k}{m}}$

$d = \frac{M}{m}\Delta x \sin(2\theta)$

Spiral 2a Test

Paterson/Janssen

b. A suspended mass ***M=25 kg*** compresses the spring by ***Δx=75 cm***. How far does the launch mass ***m=1.5 kg*** travel if launched at a 25° angle? **[1]**

$\frac{25}{1.5} \cdot .75 \cdot \sin(2(25)) = 957.556\,cm$

$\frac{M}{m} \Delta x \sin 2\theta = 9.58m$

9.58m

c. A toy car is released from rest immediately under the launch point so that it undergoes constant acceleration to catch the projectile when it lands. What is the toy car's acceleration? **[3]**

$9.8 = \frac{1}{2} a t^2$ $\quad 9.8 = \frac{1}{2} a (1.5)^2$

$a = 0.75 \cdot \frac{25}{1.5}$

$v_x = 12.5 \cos(25)$ $\quad v_x = 11.33$

$v = \sqrt{\frac{2kx^2}{m}}$ $\quad k = \frac{mv^2}{x^2}$

$\frac{1}{2} k x^2 = \frac{1}{2} m v^2$ $\quad = \frac{1.5 \cdot v^2}{0.75^2}$

d. The car (***mass 0.75 kg***) carrying the projectile now applies its brakes to create a coefficient of kinetic friction of ***0.655***. If its speed when it applies its brakes is 9.00 ms^{-1}, how far does it travel before stopping? **[2]**

$0.655 \cdot 0.75 \cdot 9.8 = 4.81\,N$ $\quad a =$

$f_f = \mu_k N$

$W = f_f \cdot d$ $\quad \Delta KE = \frac{1}{2} m v^2$

$f_f \cdot d = \frac{1}{2} m v^2$

$d = \frac{\frac{1}{2} 0.75 \cdot 9^2}{0.655 \cdot 0.75 \cdot 9.8}$ $\quad d = 6.31\,m$

$v = 11.33$ $\quad a = \frac{2(7.88)}{0.846^2}$

$t = \frac{9.58}{11.33}$

$t = 0.846$

$a = 26.77\,ms^2$

c) $v = at$

$t = v/a$

$t_{\uparrow} = \frac{v \sin\theta}{g}$ $\quad t = \frac{2v \sin\theta}{g}$

$d = \frac{1}{2} a t^2$

$9.58 =$

Spiral 2a Test

Paterson/Janssen

2. A beaker rests on a hot plate with a power rating (amount of power it draws from the circuit) of ***1800 W***. The beaker contains **250 mL** of water at a temperature of ***18°C***.

a. The following data are available:

Sp. C of water	Sp. C of ice	L_F of water	L_V of water	T_F water
4186 J/K°C	2108 J/kg°C	334 000 J/kg	2.15×10^6 J/kg	0.00°C

i. i. Define **specific latent heat**. [2]

~~amount that is transferred~~ Amount of energy needed to change the state of 1kg of a substance without changing temp.

ii. ii. The hot plate is turned on at full power. If all of the power is transferred to the water, how long will it take to bring the water temperature up to 85.0°C? [2]

$Q = mc\Delta T$ $Q = mc\Delta T$ $m = 250g$ $Q = 0.25 \cdot 4186 \cdot (85-18)$ $Q = 70155$ $T = \frac{873.3}{1800}$ 38.9 sec

iii. iii. The process takes 95 seconds to bring the water temperature up to 85.0°C. Give two possible reasons for this discrepancy. [2]

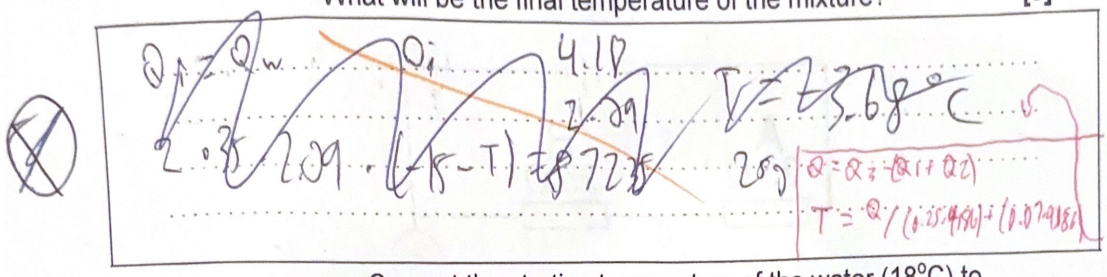
- Heat from surroundings impacting the process. SHOULDN'T CREDIT THIS.
- Inefficiencies in heat transfer

ii) $Q = mc\Delta T$
$= 0.25 \cdot 4186 \cdot (85-18)$
$= 70155.5$
$P = \frac{W}{t}$ $t = \frac{W}{P} = \frac{70155.5}{1800}$
$t = 38.9s$

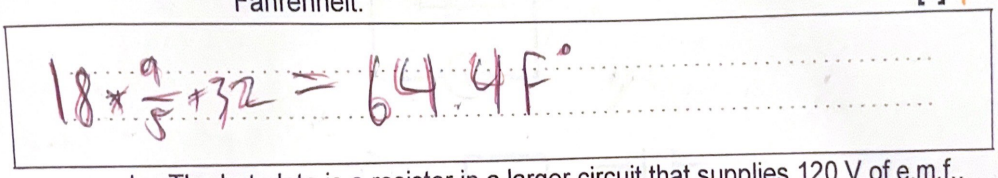
iii) heat loss from surroundings / power inaccuracies

Spiral 2a Test

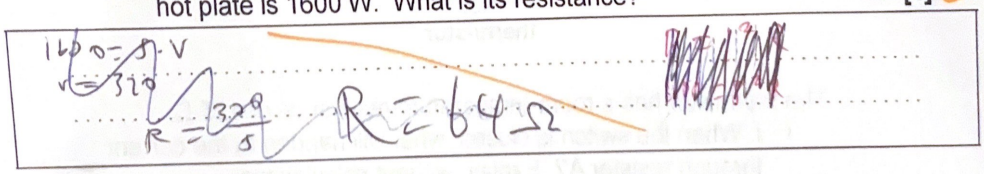
iv. iv. When the water is at 85°C, the beaker is removed from the hot plate and two 35 g ice cubes at a temperature of -15.0°C are added to the water, which is then placed in a fully insulated container. What will be the final temperature of the mixture? [3]



v. v. Convert the starting temperature of the water (18°C) to Fahrenheit. [1]

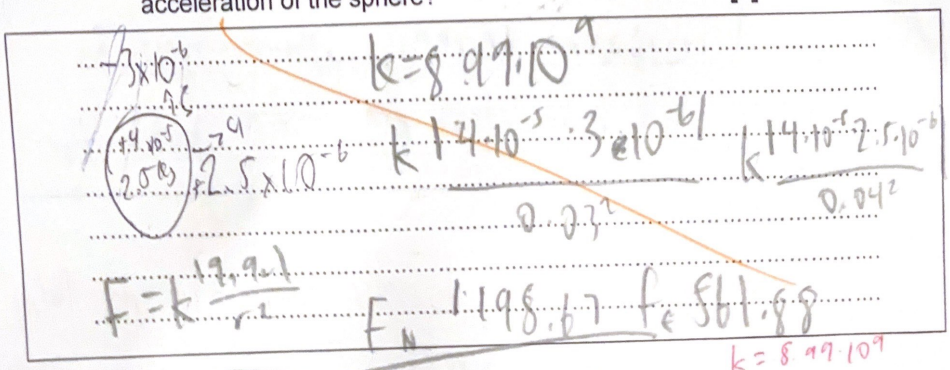


b. The hot plate is a resistor in a larger circuit that supplies 120 V of e.m.f., and runs 5.0 A through the hot plate itself. The actual power output of the hot plate is 1600 W. What is its resistance? [1]

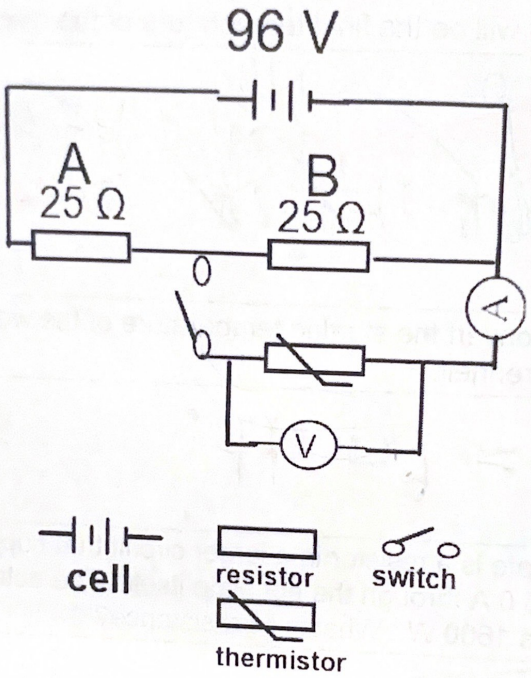


3. This question is about electricity

a. A **2.50 kg** sphere carries a charge of **+4.0x10^{-5} C**. A charge of **-3.0x10^{-6} C** is placed **3.0 cm north** of the sphere, and another charge of **+2.5x10^{-6} C** is placed **4.0 cm east** of the sphere. What is the instantaneous acceleration of the sphere? [3]



b. A circuit has a thermistor connected as shown in the diagram.



The thermistor has a room-temperature resistance of 125 Ω.

i. i. When the switch is closed, what will happen to the current through resistor A? Explain without calculations. [2]

current will decrease

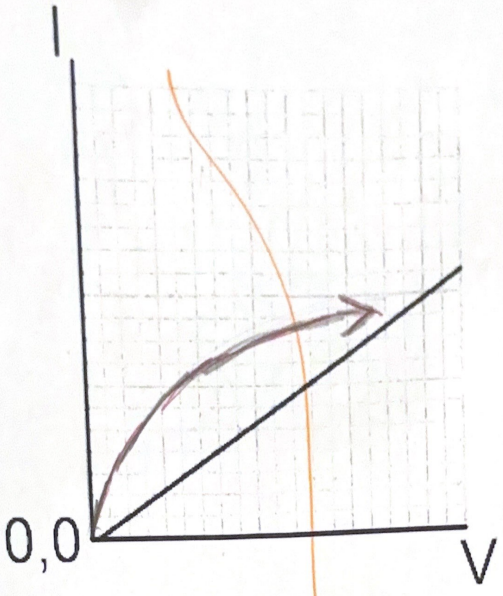
current will increase because total resistance decreases, allowing more I. the parallel connection provides a path for current

current increases due to decrease in total resistance

Spiral 2a Test

Paterson/Janssen

3



ii. ii. The graph shows the relationship between potential difference and current for an ohmic resistor. Sketch on the same axes what the graph would look like for the thermistor. **[1]**

iii. Calculate the power lost through resistor B when the switch is open. **[2]**

$I = \frac{V}{R_{total}} = \frac{9.6V}{5\Omega}$ $R = 2\Omega + 2\Omega = 5\Omega$

$P = I^2 \cdot R$

$1.92^2 \cdot 2$

$P = 92.16$

c. The current through each of the 25 Ω resistors is 1.8 Ω. What is the internal resistance of the cell? **[2]**

$V = IR$

$V = 1.8(5\Omega)$

$V = 9.0$

$\frac{\mathcal{E} - V}{I} = r$

$\frac{9.6 - 9.0}{1.8} = r$

$r = 0.33\Omega$

$r = \mathcal{E} - V$

$\mathcal{E} = 9.6$ $1.8 \cdot 5.0$

$V = IR = 9.0$

$r = \frac{9.6 - 9.0}{1.8}$

$r = 3.33\Omega$

1. In an attempt to remove competition from the Olympics, a materials scientist is attempting to make a medal made of gold, silver, ***and*** bronze. She takes 350 g of copper at 1250°C, 250 g of silver at 1100°C, and 75 g of gold at 1350°C (it's expensive!) and mixes them together. The following data are available:

Substance	Fusion T (°C)	Sp. Heat Cap ($Jkg^{-1}K^{-1}$) *Same for all states	Sp. Latent Heat of fusion ($kJkg^{-1}$)
Gold	1063	128	63.7
Silver	961	235	104.6
Copper	1084	572	215.7

a. Assuming no heat is transferred to or from the surroundings, what will be the equilibrium temperature of the mixture? **[3]**

$Q = mc\Delta T$

$T = \frac{Q}{mc}$ 1228.75

b. When the mixture is uniform, she brings it to a temperature of 1150°C. How much energy would be released to the surroundings as the mixture cools from 1150 to 1000.0°C? **[2]**

Spiral 2b Test

2. A laser of wavelength 650 nm and intensity 256 Wm^{-2} is aimed through three polarizing filters. The second filter is angled so that its polarization is 25° off the first one. What angle should the third filter be placed at to produce a final beam intensity of 64.0 Wm^{-2}? [2]

$I = I_0 \cos^2\theta$ ~~factors~~ $\theta = 39^\circ$

$I = 256 \cos^2(25)$ $64 = 256 \cos^2\theta$ ~~The angle needed = 39°~~

$I = 210$ $\cos\theta = \sqrt{64/256}$

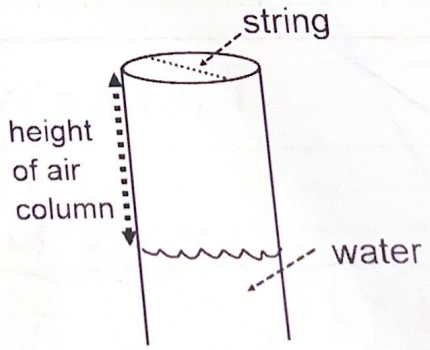
$I = I_0 \cos^2\theta$ $64 = 105 \cos^2\theta$ $\theta = 56.49^\circ$

$I = 256 \cos^2(25)$ $\cos\theta = \sqrt{64/105}$ ∴ The angle is ≈ 57°

$I = 210$ $\theta = 39^\circ$

$1/2 = 105 = 1$

3. A child wishes to make their own musical instrument by tightening a string across the open end of a plastic cylinder. The other end of the cylinder is immersed vertically in water to create a fixed end wherever the water level lies.

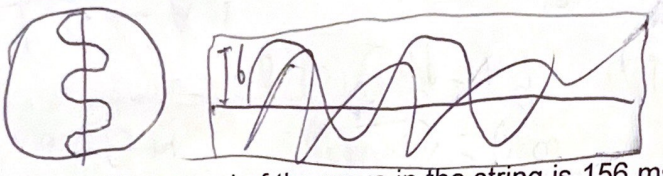


a. Define ***destructive interference***. [2]

When two waves of opposite amplitudes intersect, causing superposition that cancels out both waves and makes the new amplitude 0.

b. The diameter of the cylinder is 12.0 cm. Determine the wavelength of the wave produced at the string's fundamental frequency. **[1]**

$\lambda = 2L \quad \lambda = 2(12) \quad \lambda = 24\text{cm} \quad \therefore \lambda = 24\text{cm}$

[2] 

$\lambda = 2L \quad \lambda = 2(12)$

$\lambda = 24\text{Hz}$

c. The speed of the wave in the string is 156 ms^{-1}. The student forces the string to vibrate at its first overtone (second harmonic). If the speed of sound in air is 350 ms^{-1}, what length do they need to make the column in order to produce the second ***harmonic*** frequency? **[3]**

V = fundamental freq. $\quad v = f\lambda$

$\frac{V}{2L} \quad \frac{1f6}{2(12)} \quad 350\,ms$

$f_1 = 6.5\,ms$

$f_2 = 13\,ms^{-1}$

$f_1 = 6.5$

$f_2 = 13$

$\frac{V}{2L} = \frac{1f6}{2(12)} = 6.5 = f_1$

$f_2 = 13 = f_1 \times 2 = 6.5 \times 2$

$L = \frac{3v}{4f}$

$= \frac{3 \cdot 350}{4 \cdot 13}$

$L = 20.19\,cm$

SPH3UB

Spiral 2b Test

Paterson

4. In our noisy classroom, a teacher standing at the front of the room needs to speak loudly enough to be heard 10.0 m away near the back. Unfortunately someone there is playing a video game that produces 1.26×10^{-3} W of noise.
   a. How much sound power does the teacher have to produce to be heard at the same intensity to someone who is standing 1.0 m away from the video game?

[2]

$I = \frac{P}{4\pi r^2}$ | $\frac{1.26 \times 10^{-3}}{4\pi 1^2} = \frac{P}{4\pi 10^2}$

$0.126W$ | $P = 9.126W$

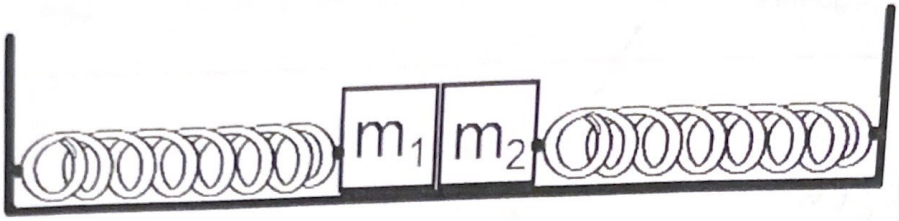
   b. A typical teenage ear canal has a diameter of 0.70 cm. How much kinetic energy is transferred to that eardrum in 5 minutes from the video game if the game is 1.5 m away? Assume no energy is lost to the surroundings.

[3]

5.147×10^{-7} J

4

5. Two identical springs of negligible mass rest on a friction-free surface.



Each is fixed at one end, with a mass on the other end, and the masses are in contact with each other. At this point the springs are not stretched or compressed. Each mass is then given a positive charge of ***A Coulombs***.

a. Demonstrate that the distance between the masses at equilibrium is given by this equation:

$$r = \sqrt[3]{\frac{k_e A^2}{2k_s}}$$ **[2]**

Where k_s is the spring constant and k_e is the Coulomb constant.

$2k_s r = k_e \frac{A^2}{r^2}$ $\quad r^3 = \frac{k_e A^2}{2k_s}$ $\quad r = \sqrt[3]{\frac{k_e A^2}{2k_s}}$

$F = k_e \frac{q_1 q_2}{r^2}$ $\quad = k_e \frac{A^2}{r^2}$ $\quad F = k_s x$ $\quad = k_s r \times 2$ $\quad = 2k_s r$

b. When the spring constant is ***125 Nm^{-1}***, the equilibrium position is when the masses are separated by a distance of 15.0 cm.

i. What is the value of the charge on each mass? **[2]**

$F = k \frac{q_1 q_2}{r^2}$ $\quad r = 15$ $\quad q^2 = 6.24 \times 10^{-11}$ $\quad$ ∴ The charge on each mass is

$125 = 8.99 \times 10^9 \frac{q^2}{r^2}$ $\quad q = 8 \times 10^{-6}$ $\quad 8 \times 10^{-6}$ C

9.69×10^{-6} C $\quad 15.0 = \sqrt[3]{\frac{k_e A^2}{2 \cdot 125}}$

$A = 9.69 \times 10^{-3}$

5

ii. The masses are 1.5 kg each. If the charges are removed when the masses are at equilibrium position, what will be the magnitude of the speed of either mass just before they collide? **[2]**

$r = \sqrt[3]{\frac{8.98 \times 10^{9}(8 \times 10^{-6})}{2.125}}$ $r = 6.6\,m$ $1.37\,m/s$

$kx^2 = mv^2$

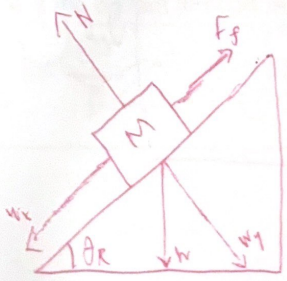
$125.8(1.5)^2 = 1.5v^2$

$2.81 = 1.5v^2$

$v = 1.3687\,m/s$

6. Two university students are carefully sliding a fragile box of mass ***M*** down a ramp angled at θ_R up from the horizontal ground.
   a. The student at the bottom slips, so that the student at the top has to hold the weight all by herself. If she pulls at an angle of θ_F up from the plane of the ramp, demonstrate that her pull force may be expressed as: **[4]**

$$mg\frac{(sin\theta_R - \mu_s cos\theta_R)}{(cos\theta_F - \mu_s sin\theta_F)}$$



Spiral 2b Test

b. The student releases the box, and the following data are available:

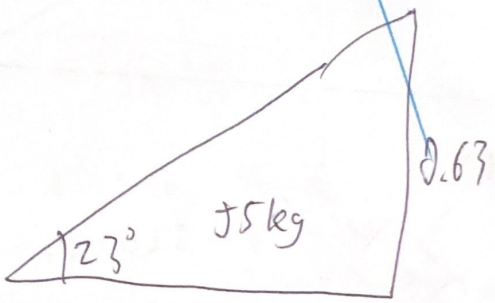
Mass of box	Angle of ramp	μ_s	μ_k	Height of ramp
55.0 kg	23.0°	0.30	0.155	0.63 m

i. Once the box is sliding, what is the magnitude of the work done by the friction force as the box slides down the full length of the ramp? **[1]**

$W = Fd\cos\theta = 0.155d\cos(23)$

$-123.93\,T$

ii. At the end of the ramp is a straight vertical drop of .75 m. With what speed will the box strike the ground? **[2]**



$mg\left(\frac{\sin\theta_R - \mu_s\cos\theta_R}{\cos\theta_F - \mu_s\sin\theta_F}\right)$

Spiral 2b Test

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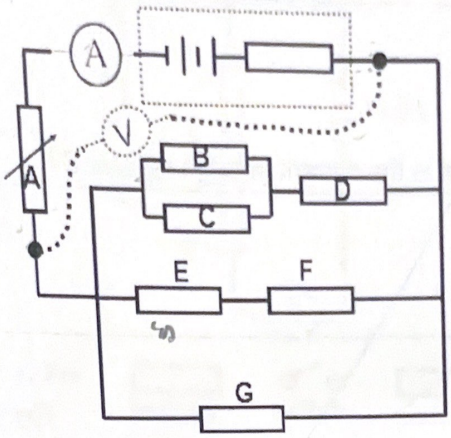
7. A circuit is set up as shown with a variable resistor and a non-ideal cell. All meters are ideal.



The following data are available:

R_A (variable)	0-6.00 Ω		R_E	3.00 Ω
R_B	6.00 Ω		R_F	6.00 Ω
R_C	6.00 Ω		R_G	9.00 Ω
R_D	6.00 Ω		V_{Cell}	120. V

a. When the circuit is connected and the variable resistor is at maximum value, the ammeter A reads 12.0 A.

i. What is the internal resistance of the cell? **[1]** 0

$R = \frac{\mathcal{E} - V}{I} = \frac{120 - 12}{12}$ $\quad \mathcal{E} = V + Ir$

ii. What is the current through resistor A (the variable resistor)? **[1]** 0

$V = IR$ $\quad I = 20A$ $\quad I = \frac{V}{R}$ $\quad I = \frac{120}{6}$ $\quad I = 20A$

iii. What is the reading on the ~~voltmeter V~~? [1]

120 − 72 = 48 48 V / 10.8 V

V = IR

iv. What is the current through resistor B? [1]

2A

b. Assuming that the current through resistor E is 4.00 A, what is the power lost due to the resistance in resistor F? [1]

Spiral 2b Test

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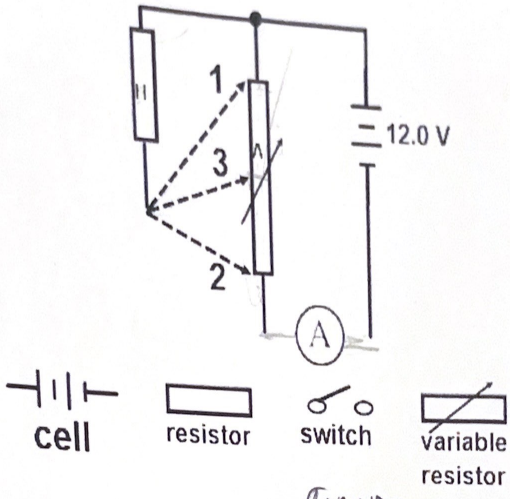
c. An unknown resistor ***H*** is tested using the variable resistor (A – 0-6.00 Ω) with an initial potential difference across A of 12.0 V from an ideal cell, as shown in the diagram. Resistor A is an ideal ohmic device.



i. What is the reading on the ~~voltmeter~~ ammeter when the slider is connected at position 1? [1] 1

$I = \frac{V}{R}$ $I = \frac{12}{6}$ $I = 2A$

ii. When the slider is connected at position 2, the ammeter reads 2.4 A. What is the resistance of resistor H? [1] 0 5D

$R = \frac{V}{I}$ $R = \frac{12}{2.4}$ $R = 5\Omega$

iii. Position 3 is exactly halfway along resistor A. At this setting, the ammeter reads 2.6 A. Explain whether resistor H is an ohmic resistor. [2] 1

No, resistance is not a multiple

$\frac{1}{30} + \frac{1}{3} = \frac{11}{30}$ $\frac{12}{63/11} =$

$\frac{30}{11} + 3 = \frac{63}{11}$