Level 2 Physics
2013
Study Answer-Booklet

Contents:

Matching Exercise Answers

Unit Review Answers:

(equation symbol, unit and situation to use with things to remember AND descriptions of diagrams) It is up to YOU to make sure you know the VOCABULARY used in these answers.

Answers to the Revision Question Sets (NOT from old national exams)

For more questions check out this website for sample 2012 exam questions:
http://www.nzqa.govt.nz/ncea/assessment/search.do?query=Physics&view=exams&level=02

L2 Mechanics Matching Answers:

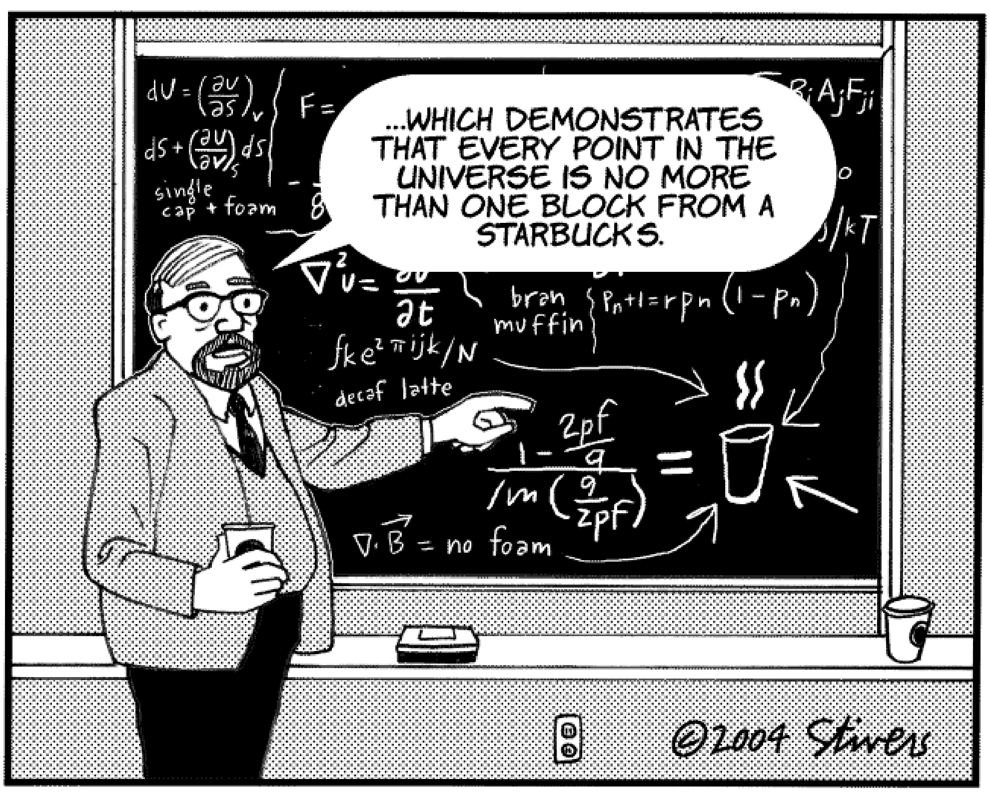
1. K
2. P
3. Y
4. S
5. E
6. I
7. YY
8. EE
9. QQ
10. DD
11. AA
12. CC
13. PP
14. M
15. HHH
16. III
17. GG
18. AAA
19. B
20. RR
21. G
22. C
23. VV
24. HH
25. GGG
26. X
27. ZZ
28. II
29. EEE
30. V
31. J
32. SS
33. R
34. Z
35. A
36. O
37. NN
38. MM
39. KK
40. CCC
41. U
42. BB
43. TT
44. JJJ
45. D
46. F
47. LL
48. H
49. FF
50. JJ
51. BBB
52. N
53. Q
54. XX
55. W
56. FFF
57. OO
58. L
59. T
60. DDD
61. WW
62. UU

L2 Waves Matching Answers:

1. K
2. MM
3. W
4. CC
5. H
6. E
7. Q
8. I
9. V
10. T
11. D
12. JJ
13. M
14. U
15. FF
16. OO
17. HH
18. AA
19. Z
20. C
21. S
22. GG
23. P
24. QQ
25. A
26. KK
27. I I
28. J
29. EE
30. RR
31. LL
32. G
33. R
34. Y
35. O
36. F
37. DD
38. BB
39. X
40. L
41. B
42. NN
43. N
44. PP

L2 E+M Matching Answers:

1. ZZ
2. C
3. W
4. WW
5. TT
6. CC
7. Q
8. QQ
9. G
10. J
11. UU
12. S
13. F
14. XX
15. O
16. DD
17. BB
18. PP
19. AAA
20. FF
21. Z
22. RR
23. X
24. I
25. MM
26. SS
27. A
28. B
29. M
30. H
31. VV
32. I I
33. U
34. YY
35. Y
36. FF
37. NN
38. N
39. LL
40. P
41. V
42. CCC
43. KK
44. D
45. AA
46. OO
47. T
48. K
49. L
50. E
51. R
52. GG
53. BBB
54. EE
55. HH



Year 12 Physics Motion Unit Review– ANSWERS

KNOW THE EQUATIONS:

		Symbol's **complete** name And SI unit	Situation where equation is most commonly used (or notes about this equation). Use your own paper
$v = \frac{\Delta d}{\Delta t}$	v	Velocity (ms^{-1})	1. Only to be used for constant speed (constant velocity). Also can be used for "average velocity" with "total displacement" and "total time"
	Δd	Change in displacement (m)	
	Δt	Change in time (s)	
$a = \frac{\Delta v}{\Delta t}$	a	Acceleration (ms^{-2})	2. Only used in 1D problems (NOT 2D!!!) Δv is $v_f - v_i$. If one of the velocities is backwards ONE MUST BE NEGATIVE!!!
	Δv	Change in velocity (ms^{-1})	
$v_f = v_i + at$ $d = v_i t + \frac{1}{2}at^2$ $d = \frac{v_i + v_f}{2}t$ $v_f^2 = v_i^2 + 2ad$	v_f	Final velocity (ms^{-1})	3,4,5,6. Assumes constant acc (no friction). Used for 1D situations (or vertical part of projectiles) ONLY. Watch out for negatives (acc or v_f or v_i) if opposite directions are involved. With free-fall: acc = gravity (given on exam)
	v_i	Initial Velocity (ms^{-1})	
	a	Acceleration (ms^{-2})	
	t	Time (s)	
	d	Distance (or displacement) (m)	

Be familiar with the COMMON DIAGRAMS and GRAPHS in this unit:

1. 1st graph: 6 parts
   - 1st part: constant velocity = 15/10 = 1.5m/s forward
   - 2nd part: stationary for 10s at 15m from starting position.
   - 3rd part: constant velocity = -15/4 = 3.75m/s backwards
   - 4th part: stationary for 3s (at same location as when they started)
   - 5th part: constant velocity = 25/4 = 6.25m/s backwards
   - 6th part: stationary for 4s at 25m behind where they started

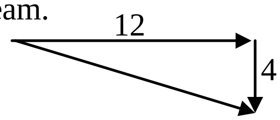
   Total distance travelled = 55m
   Total displacement = 25m behind their starting position
   Average Speed = 55/35 = 1.57m/s
   Average Velocity = -25/35 = 0.71m/s backwards

2nd graph: 6 parts
- 1st part: constant acceleration = 15/10 = 1.5m/s^2 from rest to 15m/s for 10s travelling d=area = ½ x 15 x 10 = 75m
- 2nd part: constant velocity of 15m/s for 10s travelling d=area = 15x10 = 150m
- 3rd part: decelerating at a = -15/4 = -3.75m/s^2 from 15m/s to rest in 4s travelling d=area = ½ x 15 x 4 = 30m
- 4th part: at rest (v=0) for 3s
- 5th part: accelerating in the backwards direction from rest to 25m/s in 4s. a = 25/4 = 6.25m/s^2 travelling d=area = ½ x 25 x 4 = 50m backwards.
- 6th part: constant velocity of 25m/s backwards for 4s travelling d=area = 25x4 = 100m

Total distance travelled = 75+150+30+50+100 = 405m
Total displacement = (75+150+30) – (50+100) = 225 – 150 = 105m forward
Average Speed = 405/35 = 11.57m/s
Average Velocity = 105/35 = 3m/s forwards

2. OPTIONAL QUESTION that will help you understand forces & momentums later

1st situation: boat heads straight East but drifts downstream.

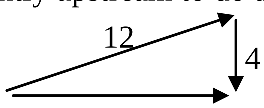


Velocity relative to river bank = $\sqrt{12^2 + 4^2}$ = 12.65m/s

Angle = $\tan^{-1}\left(\frac{4}{12}\right)$ = 18° S of E

Time to cross river = d/v = 150/12 = 12.5s
Distance drifted downstream = vt = 4x12.5 = 50m South
Distance traveled = vt = 12.65 x 12.5 = 158m

2nd situation: boat travels straight East but heads slightly upstream to do this.



Velocity relative to river bank = $\sqrt{12^2 - 4^2}$ = 11.31m/s

Heading = $\sin^{-1}\left(\frac{4}{12}\right)$ = 19.5° N of E

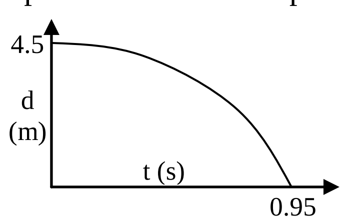
NOT same angle as 1st situation
Time to cross river = d/v = 150/11.31 = 13.26s

3. **1st situation:** d=4.5, a = 10, v_i=0

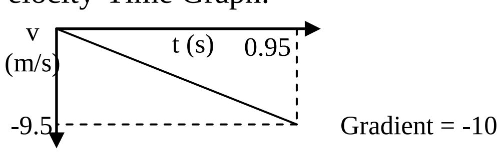
$d = v_i t + \frac{1}{2}at^2$ gives: $t = \sqrt{\frac{2d}{a}}$ =0.95s

$v_f = v_i + at$ = 9.5m/s

Displacement-Time Graph:



Velocity-Time Graph:



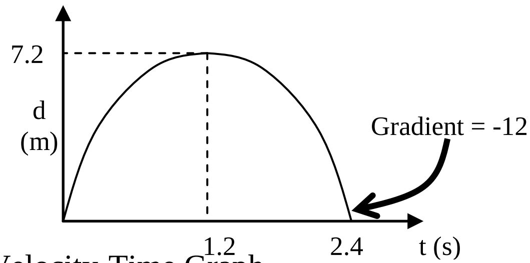
NOTE: downwards = negative direction and starting position is +4.5m above ground in these graphs

3. **2nd situation:** v_i=12, a=-10, v_f(top) = 0

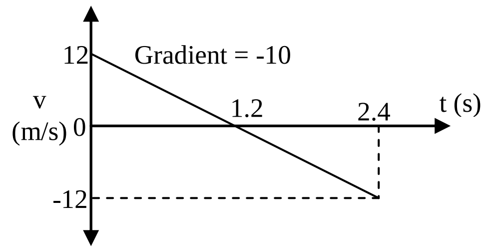
$v_f = v_i + at$ gives: $t = \frac{v_f - v_i}{a}$ = 1.2s

$d = v_i t + \frac{1}{2}at^2$ = 7.2m

Displacement-Time Graph:



Velocity-Time Graph

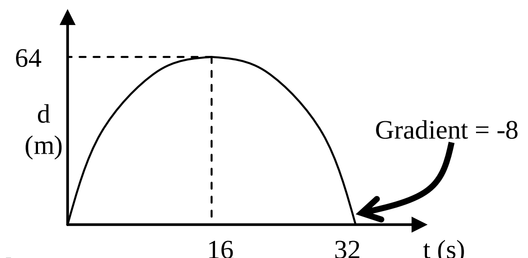


3. **3rd situation:** v_i=8, v_f(top)=0, a = -0.5

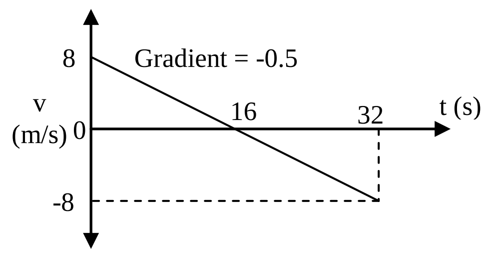
$t = \frac{v_f - v_i}{a}$ = 16s

$d = v_i t + \frac{1}{2}at^2$ = 64m

Displacement-Time Graph:



Velocity-Time Graph



4. v_i=7.5, v_f (top) = 0, a = -10

$v_f^2 = v_i^2 + 2ad$ gives: $d = \frac{v_f^2 - v_i^2}{2a}$ = 2.8m

$t = \frac{v_f - v_i}{a}$ =0.75s

Total time = 2 x 0.75 = 1.5s

5. $v_{iy}=0$, $a_y=-10$, $d_y=-185$

$d = v_i t + ½ at^2$ gives: $t = \sqrt{\frac{2d}{a}}$ =6.08s

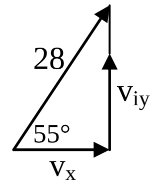
$v_f = v_i + at$ = 60.8m/s down

Range = $d_x = v_x t$ = 85 x 6.08 = 517m

Impact velocity = $\sqrt{85^2 + 60.8^2}$ = 104.5m/s

Direction = $\tan^{-1}\left(\frac{60.8}{85}\right)$ = 36° into ground

6.



a) v_{iy}= 28 sin 55 = 23m/s
   v_x= 28 cos 55 = 16m/s

b) v_{iy}= 22.936…, a = -10, v_f(top) =0

$t = \frac{v_f - v_i}{a}$ = 2.3s

Total time = 2 x 2.3 = 4.6s

c) $d = v_i t + ½ at^2$ = 26m

d) Range = $d_x = v_x t$ = 16 x 4.6 = 74m

Year 12 Physics Forces, Springs & Circular Motion Unit Review – ANSWERS

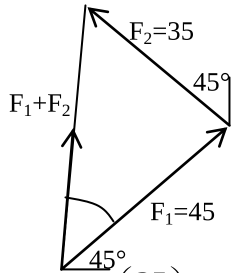
KNOW THE EQUATIONS:

		Symbol's **complete** name And SI unit	Situation where equation is most commonly used (or notes about this equation).
$F = -kx$	F	Restorative Spring Force (N)	1 **Hooke's Law**: Negative since F opposes extension. Can be linked to F=mg with Newton's 3rd Law. Stiffer spring = bigger k
	k	Spring Constant (Nm^{-1})	
	x	Extension (m)	
$F = mg$	F	Net Force (N)	2 **Weight force**. Remember to use given gravity on exam.
	m	Mass (kg)	
	g	Acceleration of gravity (9.8 ms^{-2})	
$E_p = ½ kx^2$	E_P	Elastic Potential Energy (of spring) (J)	3 Is a combination of F=-kx and area of triangle on F vs x graph. Can be done with E_p = ½ F x
$\Delta E_p = mg\Delta h$	ΔE_p	Change in Gravitational Potential Energy (J)	4 Can be used for change in mass's height when attached to spring. But only ½ of ΔE_P is stored as elastic potential energy of stretched or compressed spring.
	Δh	Change in height (m)	
$F_c = \frac{mv^2}{r}$	F_C	Centripetal Force (N)	5 Force to centre of circle (same direction as a_c). Can link with F=ma. This is combination of F=ma and $a_c = \frac{v^2}{r}$. Can include $v = \frac{2\pi r}{T}$.
	m	Mass (kg)	
	v	Velocity (ms^{-1})	
	r	Radius (m)	
$a_c = \frac{v^2}{r}$	a_c	Centripetal acceleration (ms^{-2})	6 Assumes constant speed round circle. Acc towards centre of circle with velocity tangent to circular path.
$v = \frac{2\pi r}{T}$	T	Period (s)	7 Usually not supplied on exam. Comes from $v = \frac{d}{t}$ for constant speed.
$f = \frac{1}{T}$	f	Frequency (Hz)	8 Can be used as $T = \frac{1}{f}$

<u>Be familiar with the COMMON DIAGRAMS and GRAPHS in this unit</u>

1.

1st: F_1+F_2



$\sqrt{45^2+35^2} = 57N$

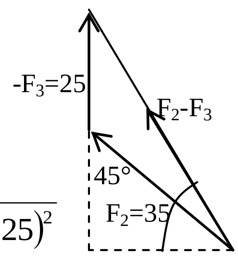
Direction (inside triangle): $\tan^{-1}\left(\frac{35}{45}\right)=37.9°$

Final Answer: F_1+F_2 = 57N at bearing of 007

2nd: F_2-F_3

components of F_2

$35\times\sin 45 = 24.75N$



F_2-F_3 with pythag:

$\sqrt{24.74...^2+(24.74...+25)^2}$

= 55.56… = 56N

Direction (inside 90° triangle):

$\tan^{-1}\left(\frac{25+24.74...}{24.74...}\right) = 64°$

Final answer: F_2-F_3 = 56N at bearing of 334

3rd: $F_2+F_1+F_3$

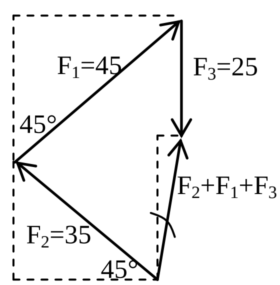
Using components:

F_1's components:

$45\times\sin 45 = 31.8198…$

F_2's components:

$35\times\sin 45 = 24.7487…$



$F_2+F_1+F_3$

Vertical component:

24.7487…+ 31.8198… - 25 = 31.568… North

Horizontal component:

31.8198…- 24.7487…= 7.071… East

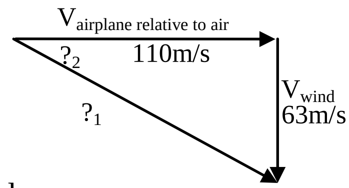
Pythag: $\sqrt{7.071...^2+31.568...^2} = 32.35… = 32N$

Direction (in small triangle): $\tan^{-1}\left(\frac{7.071...}{31.568...}\right)=$

13°

Final answer: $F_2+F_1+F_3$ = 32N at bearing of 013

2. 1st situation:



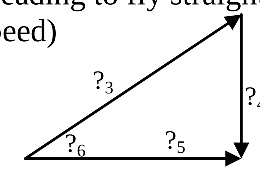
$?_1$= velocity of airplane relative to the ground =

$\sqrt{110^2+63^2} = 126.76… = 130\ ms^{-1}$

$?_2$=direction inside triangle = $\tan^{-1}\left(\frac{63}{110}\right) = 29.8…$

Final answer: 130 ms^{-1} at bearing of 120

2nd most common situation: heading to fly straight East (and new ground speed)



$?_3$= velocity of airplane relative to air = 110m/s

$?_4$= velocity of wind = 63m/s

$?_5$= velocity of airplane relative to ground =

$\sqrt{110^2-63^2}$ = 90.17…m/s

$?_6$=direction inside triangle (heading) =

$\tan^{-1}\left(\frac{63}{90.17...}\right) = 34.94… = 35°$

3. (a) Parts calculated and explained:

$?_1$= extension = x = 0.31 – 0.23 = 0.08m

$?_2$= weight force = mg = 0.365x9.8 = 3.577N

$?_3$= restorative force = weight force (when mass is stationary) = 3.577N upwards

(b) extra 0.135kg makes total m = 0.5kg

First we find the spring constant with 0.365kg and 8cm extension: $mg = kx$ makes

$k = \frac{mg}{x} = \frac{3.577}{0.08} = 44.7125 = 45\ N\ m^{-1}$

THEN we use this k with the new total mass to find the new extension:

$x = \frac{mg}{k} = \frac{0.5\times 9.8}{44.7125} = 0.109589…m$

FINALLY we add the new x to the original L of spring to get our answer:

0.23+0.109… = 0.3395… = 0.34cm

(c) If 2 identical strings used to hand 0.365kg:

new total k = addition of each individual k

= 2 x 44.7125 = 89.425 N m^{-1}

new extension will be ½ of original 8cm

extension = 4cm.

4. explanation & calculation of parts:

$?_1$= restorative force of spring in Newtons

$?_2$= extension (or compression) of spring in meters

$?_3$= spring constant (stiffness or stretchiness of spring) in Newtons per meter

calculation of k = gradient of line = $\frac{12.7-0.5}{0.21}$ = 58.09… = 58 N m^{-1}

$?_4$= elastic potential energy stored in stretched spring = area under line but only from 0.5N (not horizontal axis)

calculation of Ep = area of triangle = $\frac{1}{2}Fx = \frac{1}{2}\times 12.2\times 0.21$= 1.281 = 1.3J

$?_5$= part of graph that shows spring being overstretched. Spring constant gets smaller and smaller with too much mass or force applied.

5a names, descriptions & calculations:

$?_1$= tangential velocity of mass moving in constant speed circular motion in m/s.

Calculation: $v = \frac{2\pi r}{T} = \frac{2\pi\times 2.7/2}{12.7/5.5}$ = 3.673… = 3.7m/s

$?_2$ and $?_3$ = Centripetal force and centripetal acceleration (both to centre of circle). F_C also called net force or tension and sometimes friction in Newtons.

Calculations: $a_C = \frac{v^2}{r} = \frac{3.673...^2}{1.35}$ = 9.995… = $1.0\text{x}10^1 \text{m/s}^2$ (2SF answer)

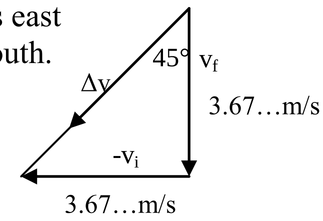
$F_C = ma_C = 4.1\times 9.995...$ = 40.982… = 41N

<u>**Comments on magnitude (sizes) of answers**</u>:

Acceleration of 9.995m/s^2 is just over gravity of 9.8m/s^2 so there will be just over 1g of acceleration and force. Thus the tension of the string must be able to take 41N which is just over the weight force of 4.1x9.8=40.18N. Otherwise the string will break and the 4.1kg mass will travel off at constant speed of 3.7m/s tangent to the circle until another force acts on it.

5b Δv for any ¼ turn:

I chose v_i=3.673… m/s east and v_f = 3.673…m/s south.



Calculation:

$\sqrt{3.673...^2 + 3.673...^2}$ = 5.195… = 5.2m/s

Direction (in this triangle) = sough west

BUT direction of Δv is always into the circle (to the centre of the circle).

6a. a_C = 2.5 x 9.8 = 24.5ms^{-2} to centre of circle

$F_C = ma_C = 1560\times 24.5$ = 38,220 = 38,000N to centre of circle

Tangential velocity = 75/3.6 = 20.8333…m/s

$a_C = \frac{v^2}{r}$ makes:

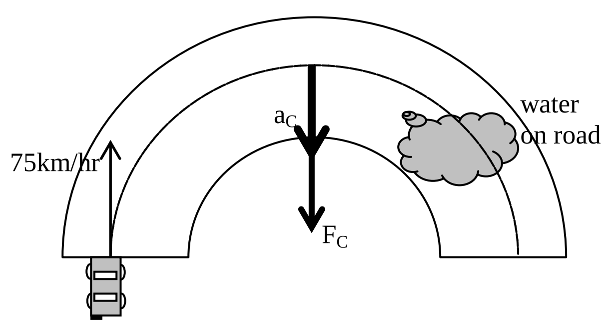
$r = \frac{v^2}{a_C} = \frac{20.83...^2}{24.5}$ = 17.715… = 18m

Period: $v = \frac{2\pi r}{T}$ makes:

$T = \frac{2\pi r}{v} = \frac{2\pi 17.71...}{20.83...}$ = 5.342…seconds

Time to make 180° turn = ½ T = 2.671… = 2.7s

6b



6c When car reaches wet patch there will not be enough friction between the wheels and the road to create the centripetal force of 38kN to make the 75km/hr constant speed corner of radius 18m.
The car will still have 25kN of force so will still have some F_c but not enough to stay on the dotted line in the diagram (18m radius curve).

If the speed stays the same at 20.83…m/s then the new radius of curve while the car is in the wet patch is: $r = \frac{mv^2}{F_C} = \frac{1560 \times 20.83...^2}{25,000} =$ 27.08… = 27m.

This means when the car is on the wet road the car will still move in a curve of 27m with larger radius than 18m but the car will "slip" off the road where the friction will change again.

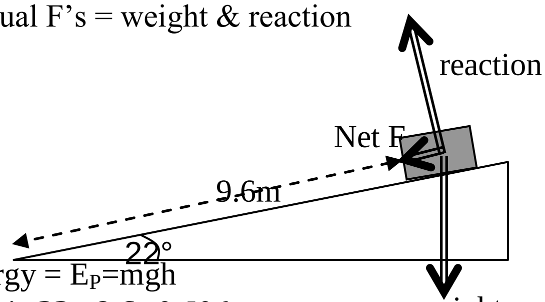
Level 2 Physics Energy, Momentum & Torque Unit Review Sheet – ANSWERS

KNOW THE EQUATIONS:

		Symbol's **complete** name And SI unit	Situation where equation is most commonly used (or notes about this equation). Use your own paper
$E_k = \frac{1}{2}mv^2$	E_K	Kinetic Energy (J)	1. can be paired with Ep = mgh for energy conservation (assumes no friction or energy-loss). Used to find elastic vs inelastic collisions (no energy loss vs energy loss)
	m	Mass (kg)	
	v	Velocity (ms^{-1})	
$\Delta E_p = mg\Delta h$	ΔE_P	Change in Gravitational Potential Energy (J)	2. can be paired with W = Fd or $E_k = \frac{1}{2}mv^2$.
	g	Gravity (acceleration) (ms^{-2})	
	Δh	Height (m)	
$E_p = \frac{1}{2}kx^2$	E_P	Elastic Potential Energy (of spring) (J)	3. Is a combination of F=-kx and area of triangle on F vs x graph. Can be done with E_p = ½ F x
	k	Spring constant (Nm^{-1})	
	x	Extension (m)	
$W = Fd$	W	Work (change in energy) (J)	4. can be paired with any other energy equation. Net force must be parallel to distance moved. Also used to find "average force to stop objects".
	F	Net force (N)	
	d	Distance moved (m)	
$P = \frac{W}{t}$	P	Power (W)	5. AKA "rate of energy used". Alternative unit for Watt: Joule per sec.
	t	Time (s)	
$p = mv$	ρ	Momentum ($kgms^{-1}$)	6. Needs DIRECTION. Can be 1D or 2D. 2D requires triangles! Used in Conservation of Momentum (total before = total after). Negative momentum vectors must be turned 180° and "added"
	m	Mass (kg)	
	v	Velocity (m/s)	
$\Delta p = F\Delta t$	Δρ	Impulse ($kgms^{-1}$)	7. Alternative unit for $kgms^{-1}$ (Ns). Can be paired with F=ma Force used to change momentum (and speed) for impacts, crashes or collisions.
	F	Contact force (N)	
	Δt	Time of contact (s)	
$\tau = Fd$	τ	Torque (Nm)	8. Also known as "moment". F and d must be 90°. Two possible directions (clockwise, anti-clockwise)
	F	Force perpendicular to distance from pivot (N)	
	d	Distance (force from pivot) (m)	

Be familiar with the COMMON DIAGRAMS and GRAPHS in this unit:

1. individual F's = weight & reaction



Total Energy = E_P=mgh
Height = $\sin 22 \times 9.6$=3.596…m
E_P = 1.8 x 9.8 x 3.596… = 63.43… = **63J**

All E_P at top of ramp will get converted to E_K at bottom of ramp assuming no friction (E lost to heat/sound).

$E_k = \frac{1}{2} m v^2$ gives

$$v = \sqrt{\frac{2E_k}{m}} = \sqrt{\frac{2 \times 63.43...}{1.8}}$$ = 8.39… = **8.4m/s**

2.
(a) Total momentum: (using before information)
$\rho_T = m_1 v_1 + m_2 v_2$ = 3.2 x 1.3 + 2.6 x (-2.5) = -2.34
so total ρ is 2.34kgm/s to the left.
Since masses stick together and total momentum before = total momentum after:
For "after" we use: $\rho_T = m_T v$

$v = \frac{\rho_T}{m_T} = \frac{2.34}{3.2+2.6}$ = 0.4034… = **0.40m/s to the left**

(b) $\Delta\rho_{2.6kg} = mv_{after} - mv_{before}$
= 2.6 x (-0.40) – 2.6 x (-2.5) = 5.46
= **5.5 kgm/s to the right**

(c) $\Delta p = F\Delta t$ gives: $F = \frac{\Delta p}{\Delta t} = \frac{5.46}{0.13}$ = **42N**

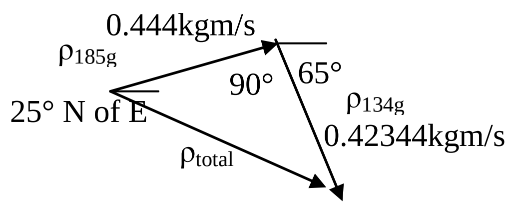
(d) Total E_K Before =
$\frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 = \frac{1}{2} \times 3.2 \times 1.3^2 + \frac{1}{2} \times 2.6 \times 2.5^2$
= 10.829J
Total E_K After = $\frac{1}{2} m_T v^2 = \frac{1}{2} \times 5.8 \times 0.40^2$ = 0.464J
Total E_K before is NOT EQUAL to total E_K after so the collision is **inelastic**.

3
(a) the $\Delta\rho_{3.2kg} = mv_{after} - mv_{before}$
= 3.2 x (-0.2) – 3.2 x 0.7 = – 2.88
So the answer is **2.9 kgm/s to the left**

(b) using conservation of momentum:
$\Delta\rho_{3.2kg}$ is equal and opposite to $\Delta\rho_{2.6kg}$
And $\Delta\rho_{2.6kg} = mv_{after} - mv_{before}$
2.88 = 2.6 x v_{after} – 2.6 x (-1.9)
v_{after} = – 1.011… = –1.0m/s
= **1.0m/s to the left**

4 is OPTIONAL: 2-D momentum situation. But this will help you in L3phy

4 (a) total momentum vector diagram:

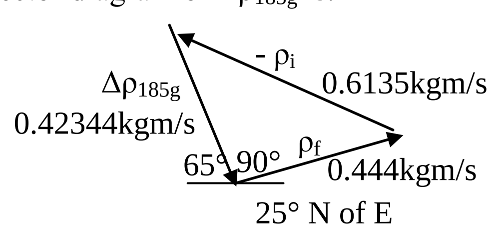


(b) must find total momentum first:
$\rho_T = \sqrt{0.444^2 + 0.42344^2}$ = 0.6135…kgm/s
Direction: (inside triangle) =
$\tan^{-1}\left(\frac{0.42344}{0.444}\right)$ = 43.64… = 44°.
Final direction = 44-25 = 19° S of E

Since only the 185g was moving before the collision it must have had ALL the momentum of 0.61kgm/s at 19° S of E. So finally:

$v = \frac{\rho}{m} = \frac{0.6135}{0.185}$
= **3.3m/s at the same direction of 19° S of E**

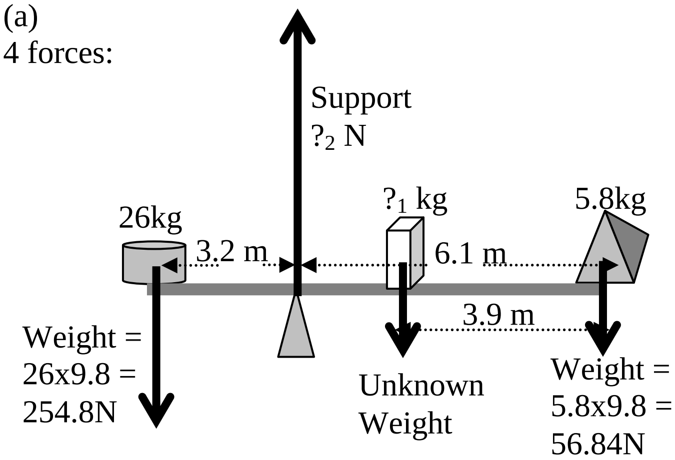
(c) vector diagram of $\Delta\rho_{185g}$ is:



5 Part 1 (beam has no mass)

(a)

4 forces:



(b) To calculate torque we need distance from mass to pivot: box to pivot = 6.1 – 3.9 = 2.2m

Box and pyramid make anticlockwise torques.

Total anticlockwise torque =

$F_{box}d_{box} + F_{pyramid}d_{pyramid}$ But we don't know weight force of the box!

BUT total $\tau_{clockwise} = \tau_{anticlockwise}$

$\tau_{clockwise} = F_{cylider}d_{cylinder} = 254.8 \times 3.2 =$ 815.36Nm

So $\tau_{anticlockwise}$ **= 815.36Nm**

(c) To find mass of box we use:

$\tau_{total} = F_{box}d_{box} + F_{pyramid}d_{pyramid}$ and F=mg

$815.36 = F_{box} \times 2.2 + 56.84 \times 6.1$

F_{Box}= 213.01… N

$m_{box} = \frac{F_{box}}{g} = \frac{213.01...}{9.8}$ = 21.73… = **22kg**

(d) Single support force must be sum of all downward weight forces.

254.8 + 213.01… + 56.84 = 524.65… = **520N**

5 part 2 (beam with mass of 12kg)

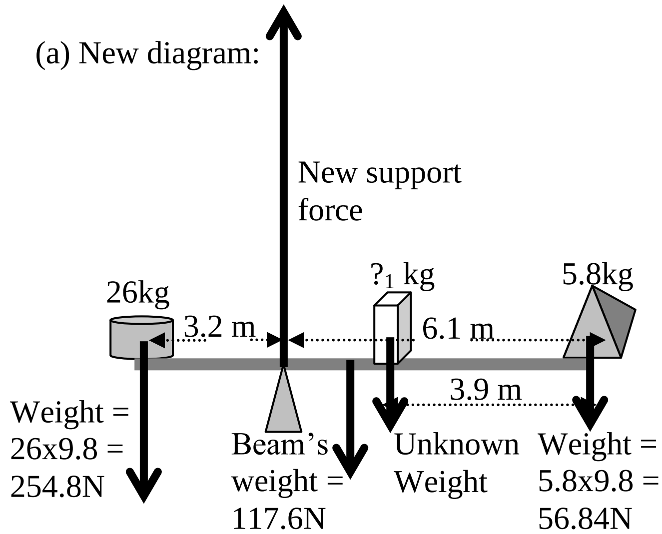
WE DO NOT KNOW THE MASS OF THE BOX

4th weight force must be added to diagram.

Weight of beam = 12x9.8 = 117.6N at centre of 9.3m long beam.

Center of beam is 1.45m to the right of the pivot (9.3/2 – 3.2 = 1.45m)

(a) New diagram:



(b) new force (beam's weight) makes new anticlockwise torque not included in "part 1"

BUT $\tau_{clockwise}$ has not changed and is still 815.36Nm.

So $\tau_{anticlockwise}$ **is still = 815.36Nm**

(c) to find mass of box we now have to add 3 torques:

$\tau_{total} = F_{beam}d_{beam} + F_{box}d_{box} + F_{pyramid}d_{pyramid}$

$815.36 = 117.6 \times 1.45 + F_{box} \times 2.2 + 56.84 \times 6.1$

F_{Box} now = 135.5… N

$m_{box} = \frac{F_{box}}{g} = \frac{135.5...}{9.8}$ = **13.8… = 14kg** (2 SF)

(d) Single support force must be sum of all downward weight forces.

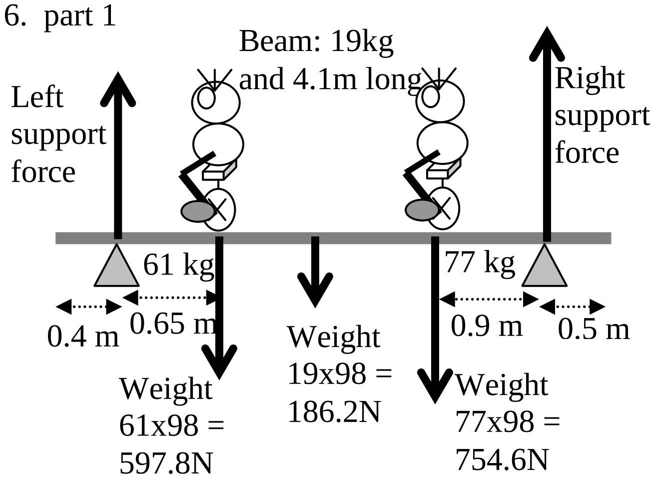
254.8 + 117.6 + 135.5… + 56.84 =

= 564.7… = **560 N**

This is less than part 1 (d) but that's OK since the box has a smaller mass of 30kg this time.

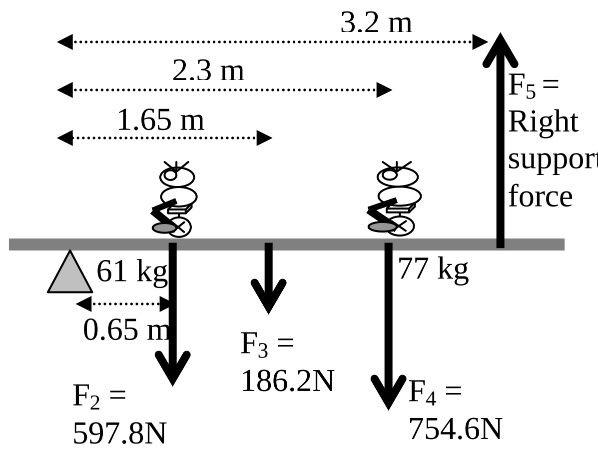
So even with the extra 12kg of the beam the support force is smaller in part 2

6. part 1



6. Part 2: To find "right support force" we need to act like the right support triangle is not there.

Most kids need a new diagram with all distances calculated from "left support pivot" to each force. The "left support force" is not included as it has a 0 distance to the pivot.



Total clockwise torque = total anticlockwise torque

$$\tau_2 + \tau_3 + \tau_4 = \tau_5$$

$$597.8 \times 0.65 + 186.2 \times 1.65 + 754.6 \times 2.3 = F_5 \times 3.2$$

$$2431.38 = F_5 \times 3.2$$

F_5 = 759.80625 = **760N**

To find the other support force we only need to use: Total downward forces = Total upward forces

$F_1 + F_5 = F_2 + F_3 + F_4$

$F_1 = F_2 + F_3 + F_4 - F_5$

F_1 = 597.8 + 186.2 + 754.6 – 759.80625 = 778.79…

F_1 = 780N

Year 12 Physics Electric Field & DC Circuit Unit Review – ANSWERS

KNOW THE EQUATIONS:

$E = \frac{V}{d}$	E	Electric Field (Vm^{-1})	1. Usually for E-field between capacitor plates of voltage V and distance of separation d. Alternative unit for E-field: (NC^{-1}) Has DIRECTION: E-filed from + to – and shows direction a + charge would move if inside E-field.
	V	Voltage (V)	
	d	Distance (m)	
$F = Eq$	F	Electric Force (N)	2. Usually for electric force on electron or dust in between capacitor plates. Can be paired with $E = \frac{V}{d}$. AND used of Millikan's experiment with F=mg
	E	Electric Field (NC^{-1})	
	q	Charge (C)	
$\Delta E_p = Eqd$	ΔE_p	Change in electrical potential energy (J)	3. Used for charged bits in electric field (test charges). Energy gained or lost as charged bits move through E-field or across potential lines. Test charge usually assumed to be positive. + charge moved to higher potential: GAINS energy - charge moved to higher potential: LOSES energy
	E	Electric Field (Vm^{-1}) or (NC^{-1})	
	d	Distance moved (m)	
$I = \frac{q}{t}$	I	Current (A)	4. Definition of electrical current – "flow of charge" or "rate of flow of charge". Conventional Current: from + to -. Electron flow opposite way.
	t	Time (s)	

$V = \frac{\Delta E}{q}$	V	Voltage (potential difference) (V)	5. Definition of potential difference (voltage): energy changed from electrical potential to light/heat as charge passes. Can be used to find energy lost or gained by charge crossing potential lines.
	Δ E	Change in energy (work) (J)	
$V = IR$	V	Voltage (V)	6. **Ohm's Law**: technically only for ohmic resistors: straight, diagonal line on V vs I graph (with R = slope).
	I	Current (I)	
	R	Resistance (Ω)	
$P = IV$	P	Power (W)	7. aka "rate of change of energy" and can be paired with $P = \frac{\Delta E}{t}$ or $V = IR$. There are 2 more equations possible: $P = \frac{V^2}{R}$ and $P = RI^2$
$P = \frac{\Delta E}{t}$	P	Power (W)	8. see above (#25)
	Δ E	Change in energy (work) (J)	
$R_T = R_1 + R_2 + ...$	R_T	Total resistance (series) (Ω)	9. ONLY for series circuit resistors. Can be used in complex circuits but only AFTER parallel bits have been simplified and reduced to equivalent series resistors.
$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + ...$	R_T	Total resistance (parallel) (Ω)	10. ONLY for parallel circuit resistors. If a "row" has more than one R in series they must be added BEFORE using the equation.

Be familiar with the COMMON DIAGRAMS and GRAPHS in this unit:

1. Calculations:

Electric Field (uniform between plates) =

$E = \frac{V}{d} = \frac{24}{0.0025}$ = 9600 V m^{-1}

$?_1$ = uniform electric field from + plate to – plate.
$?_2$ = non-uniform electric field: arrows are drawn farther and farther apart to show decreasing electric field strength.

Electric field gets created because 24V source connected to capacitor.

Negative electrons drift (get pushed) out of left side of power source, down to left capacitor plate. This creates negative charge on left plate which pushes electrons on right-side plate away, making right-side plate positive.

Any charge will have an electric field around it. Electric fields always point from + to – charges. Since capacitor plates are parallel, the electric field between them is uniform (constant).

2a

Electric field between plates (uniform):

$E = \frac{V}{d} = \frac{12}{0.0023}$ = 5217.3913… V m^{-1}

Electric forces: $F = Eq$

For m_1: $F = Eq = 5217.39... \times 0.0034$
= 17.739… = 17.7N to the right.

For m_2: $F = Eq = 5217.39... \times 0.0027$
= 14.086… = 14.1N to the left.

For m_3 and m_4 electric force is the same, but in opposite directions since protons & electrons have equal & opposite charges:

$F = Eq = 5217.39... \times 1.6 \times 10^{-19}$
= 8.3478… x 10^{-16} N

Electric force on proton (m_3) is to the right.
Electric force on electron (m_4) is to the left.

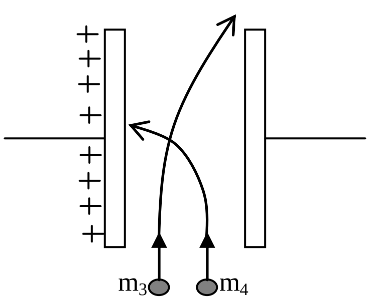
2b) energy change: $\Delta E_p = Eqd$ where d = distance the mass moves (NOT the d between the plates)
$\Delta E_p = Eqd$ can be rewritten as the work formula since $F = Eq$. So we can use $\Delta E_p = Fd$ since we just found the forces involved.
For m_1 it will move 1/4th the 2.3mm plate gap:
$\Delta E_p = Fd = 17.739... \times 1/4 \times 0.0023 = 0.0102\text{J}$
For m_2 it will move ½ the 2.3mm plate gap:
$\Delta E_p = Fd = 14.086... \times 1/2 \times 0.0023 = 0.0162\text{J}$
We cannot do the calculations for m_3 or m_4 since we don't know their positions when they enter the uniform electric field AND we don't know how far they'll move left or right.

2c) For m_3 & m_4 shot into the uniform E-field:
Since small forces we found above is 90° to velocity both m_3 & m_4 start moving in circles (arcs) inside the electric field.

For m_3 (proton): gets pushed to the right and curves that way (possibly hitting negative plate)
For m_4 (electron): gets pushed to the left and curves that way (possibly hitting positive plate)

Both act LIKE horizontally shot projectiles BUT they are shot upwards and F is not weight force, it's electric force.

Diagram:



NOTE: m_4 is an electron and MUCH smaller mass than m_3 so the same force each experiences will make m_4 curve much more quickly.

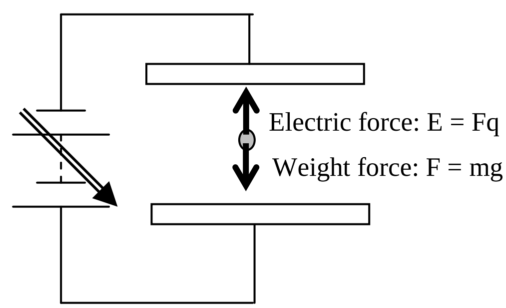
3a) This is Millikan's Oil Drop Experiment.
A strong voltage source makes a strong uniform electric field between the horizontal capacitor plates. The top plate is negative (bottom is positive) so the uniform electric field is UPWARDS (from + to -).

Millikan squirted oil drops into the space between the plates (in a vacuum). The oil drops had static charge. Some rose up, some fell down, and some stayed in the middle (levitated).

He measured the diameter of each levitating oil drop (with microscope), used the density to calculate its mass, then used the electric force equations to find the charge of the levitating oil drop.

He found that every charged oil drop was a WHOLE MULTIPLE of 1.6 x 10^{-19}C. Thus he found the "elemental charge", the smallest possible + or – charge.

3b) Forces in diagram:



3c) Weight Force: using 2.3 x 10^{-6}g = 2.3 x 10^{-9}kg
$F = mg = 2.3 \times 10^{-9} \times 9.81 = 2.2 \times 10^{-8}\text{N}$

3d) Electric field:
$$E = \frac{V}{d} = \frac{45}{0.0035} = 12{,}857.142\ldots \text{V m}^{-1}$$
Electric force = weight force:
$F = mg = Eq$ makes:
$$q = \frac{mg}{E} = \frac{2.2 \times 10^{-8}}{12{,}857.142...} = 1.7549 \times 10^{-12}\ \text{C}$$

3e) Oil drop must be POSITIVE to have upwards electric force (away from + plate).
So we find the number of "missing" electrons:
$$\frac{q}{e} = \frac{1.7549 \times 10^{-12}}{1.6 \times 10^{-19}} = 10{,}968{,}125 \text{ missing electrons}$$

4a) Total Resistance is 7.5 + Parallel R Block

Parallel R block:

$\frac{1}{R_P} = \frac{1}{15} + \frac{1}{25}$ gives $R_P = 9.375\Omega$

Total R = 7.5 + 9.375 = 16.875Ω

Total Current = $\frac{V_{TOT}}{R_{TOT}} = \frac{35}{16.875}$ = 2.074… = 2.1A

This is the reading of ammeter number one.

Ammeter # 2 & 3 must add up to 2.074…A

The 15 Ω and 25 Ω resistors use the same voltage (less than 35).

The 7.5 Ω resistor has all 2.074… amps… so it uses V=IR = 2.074… x 7.5 = 15.555…volts

This leaves 35 – 15.555… = 19.444…volts for each of the top & bottom parallel resistors.

Ammeter number 2:

$\frac{V_{parallel}}{R_{top}} = \frac{19.444...}{15}$ = 1.296… = 1.3A

Ammeter number 3:

$\frac{V_{parallel}}{R_{bottom}} = \frac{19.444...}{25}$ = 0.777… = 0.78A

5 **For OPTIONAL graph #1:** this is a Voltage vs Current graph for diodes (or LED).

This may help you understand V vs I graphs but should NOT be on your exam.

$?_1$ = voltage axis (in volts) or "voltage across the diode"

$?_2$ = current axis (in amps) or "current running through the diode)

$?_3$ = the voltage most diodes 'use' (about ½ volt)

$?_4$ = the minimum current needed for a LED to light up or another diode to let current flow "easily". This is a TINY amount, usually in the milli amps.

$?_5$ = the gradient of the curve that flattens out. The gradient of this graph is the resistance of the diode. Because the curve is almost flat the diode has almost no resistance with current flowing through it.

$?_6$ = a large number of NEGATIVE volts (around -40V) so that if you put a diode on backwards (+ connected to -) then you'll need about 40V before the diode fails and allows current through the circuit "the wrong way".

5 **For graph #2:** This is NOT the usual V vs I graph.

This is a current vs voltage graph.

The gradient of a V vs I graph would be resistance.

But the gradient of an I vs V graph is the inverse of resistance, or $\frac{1}{R}$.

The 3 lines:

$?_7$ = a straight line with constant resistance of $R = \frac{1}{gradient}$. Resistors with constant R are usually made of ceramic or clay.

$?_8$ has a decreasing gradient… So the resistance of this object would be **increasing** with higher voltage or current. This matches how filament light bulbs work.

$?_9$ has an increasing gradient… So the resistance of this object would be **decreasing** with higher voltage or current. This matches how diodes & LEDS work. This also matches how thermistors work.

Number 6 is OPTIONAL & has components in the circuit not overtly mentioned in your exam notes

6 Circuit components: starting with the power source and going CLOCKWISE:

1st: the power source is a "power pack" that is not able to have voltage adjusted (no arrow).

2nd: To the right is an LED (light emitting diode) that allows conventional current to flow in the direction of the "arrow" symbol. This LED is put into the circuit the correct way to allow current to flow. LED's are "non-ohmic", or resistance changes depending on the voltage and current. Graph #1 in number 5 showed how R changes in LEDs.

3rd : on the right of the circuit is a "regular light bulb". These have filaments and are non-ohmic resistors. Most of the energy is converted into heat, with a small portion converted into light as the current flows through the filament and the bulb uses up voltage. The more current, the higher the resistance of the filament.

4th : on the bottom right: an LRD (light dependent resistor). Another non-ohmic resistor. A chemical compound absorbs light, goes through chemical reaction and changes the resistance. Low-light = high resistance (1 mega-ohm). Bright-light = low resistance (100 ohms).

5th: bottom left: Thermistor. A temperature-dependent resistor. Non-ohmic. Cold conditions = high resistance (kilo-ohms). Hot conditions = low resistance (hundreds of ohms).

6th: on the left side: Variable Resistor, also known as "rheostat" or "potentiometer". Usually it is made of a very long wire with a "slider". The slider allows more (or less) of the long wire to be used as the resistor. Most are non-ohmic and change to higher resistances as the wire heats up.

7th: on the top left: diode. Similar to LED but does not light up. Non-ohmic. Graph #1 of #5. This diode is correctly connected for current to flow.

Year 12 Physics Magnetic Fields, Forces & Induced Voltage Review ANSWERS

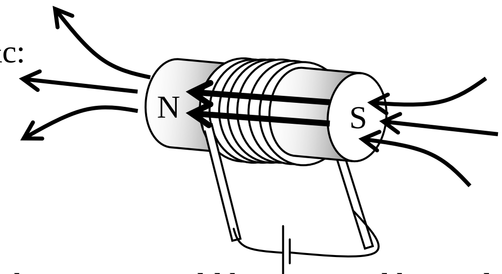
KNOW THE EQUATIONS:

Equation		Symbol's **complete** name And SI unit	Situation where equation is most commonly used (or notes about this equation). Use your own paper
$V = IR$	V	Voltage (V)	1. **Ohm's Law**: technically only for ohmic resistors: straight, diagonal line on V vs I graph (with R = slope).
	I	Current (I)	
	R	Resistance (Ω)	
$P = IV$	P	Power (W)	2. aka "rate of change of energy" and can be paired with $P = \frac{\Delta E}{t}$ or $V = IR$. There are 2 more equations possible: $P = \frac{V^2}{R}$ and $P = RI^2$
	I	Current (I)	
	V	Voltage (V)	
$F = BIL$ or $F = BIL(\sin\theta)$	F	Lorentz Force (N)	3. Sometimes given as F=BIL without sinθ when θ=90° Uses Right-Hand-Slap-Rule: thumb = I, fingers = B, palm = F. Force involved in electric motors and current carrying wire in B-fields. "Current in B-field causes Lorentz Force"
	B	Magnetic Field (T)	
	I	Current (A)	
	L	Length of wire in B-field (m)	
	θ	Angle between B and I (°)	
$F = Bqv$	F	Lorentz Force (N)	4. Also the Lorentz Force (like #29) but for charged particles shot into B-field at velocity. Uses Righ-hand-slap rule: fingers = B, palm = F BUT thumb = motion of POSITIVE particle. If negative particle – must have thumb pointing opposite direction to particle's velocity.
	q	Charge of particle (C)	
	v	Velocity of particle (ms^{-1})	
$V = BvL$	V	Induced Voltage (V)	5. For "rail" pulled across B-field. F=BIL shows up as opposing force with right-hand-slap-rule to determine direction of current. Usually with galvanometer to show direction of current. Commonly asked for "which side of rail is +?". Must think of "rail" as "battery".
	v	Velocity of wire (ms^{-1})	
	L	Length of wire crossing B-field (m)	

Be familiar with the COMMON DIAGRAMS and GRAPHS in this unit:

1a. $B = \frac{\mu_o N I}{L} = \frac{1.26\times10^{-6}\times7\times{}^{12}\!/_{1.45}}{0.048}$
$= 1.52\ldots \times 10^{-3} = 1.5 \times 10^{-3}$ T

1b&c:



1d: The current could be increased by applying more voltage or decreasing the resistance of the coil. With more current each wire (turn) will have a stronger magnetic field. This will make for a stronger magnetic field inside the coil as current and magnetic field inside are directly proportional.

More turns of wire could be added to the coil. This would increase the magnetic field as turns and B-field are directly proportional.

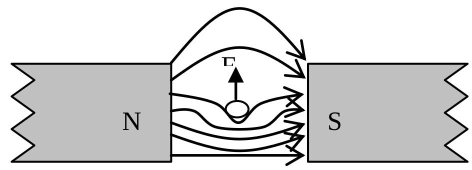
An iron core could be added (or more iron could be added to the existing core) but keeping the same dimensions. A magnetic material in the core with its own magnetic domains would amplify the magnetic field made by the coil of current carrying wire.

2a. Current must be "out of the page" and a "dot" must be drawn in the circle.

2b. This is a situation for the right hand slap rule where the Lorentz Force from F=BILsinθ on a current carrying wire inside an existing magnetic filed, B, where the angle between I and B is θ and the wire is only in the magnetic field for a length L. Since the wire has current it has its own circular magnetic field, anticlockwise in this case. The existing magnetic field goes from N to S (right). Below the wire the 2 magnetic fields add together, above the wire they subtract to make a stronger B-field below and a weaker B-field above the wire. The Lorentz Force is away from strong B-fields.

The right hand slap rule can be used: fingers = existing B-field, thumb = current in the wire, out of palm = Lorentz Force on wire with current.

2c.



2d. $F = BIL(\sin\theta)$ with θ = 90 makes

$I = \frac{F}{BL} = \frac{2.45\times10^{-3}}{35.8\times10^{-3}\times0.48}$
$= 0.1425\ldots = 0.14$A

3a. $F = BIL(\sin\theta) = 1.9\times3.3\times0.75\times\sin 52 =$
$3.7056\ldots = 3.7$N

3b. F is "into the page". The Lorentz force comes from the current (or charges) crossing magnetic field lines. The Right Hand Slap Rule gives the directions (each 90° to each other): fingers = B-field, thumb = conventional current, thumb = Lorentz Force.

3c.
(i) With 38° rotation W of N the wire's current would be 90° to the B-field: Force would be the largest possible value of $F = BIL(\sin 90) = 1.9\times3.3\times0.75 =$ 4.7N
(ii) With 52° rotation E of N the wire's current will be in the same direction as the B-field so no force will exist on the wire since no current is crossing B-field lines and $F = BIL(\sin 0) =$ 0N

4 (the motor) is OPTIONAL but will help you understand F=BIL. Motors may not be on your exam. Other F=BIL questions/situations will.

4a. Missing power source must have + terminal on the right and – terminal on the left.

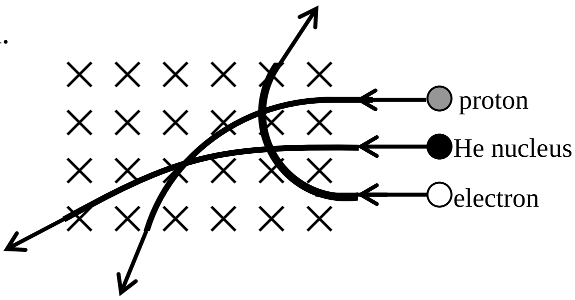
4b. X = wire brush made of carbon. Carbon is used because it is a good conductor and minimizes friction (is actually a lubricant in this situation).
Y = comutator ½ circles. These spin around, each in contact with a single brush at any instant so that the current in the coil is able to change direction as the coil spins.

4c. $B = \frac{F}{IL} = \frac{0.019}{1.2\times0.23} = 0.06884\ldots = 0.069$T

4d. $F_{NET} = NBIL = NF_{Single} = 350 \times 0.019$ = 6.65N

This is the net force on one side of the coil. Each side has 6.65N making two torques in the same direction. This much larger torque (700 times as much) makes the motor spin much faster.

5a.



5b. Proton:

$F = Bqv = 2.95 \times 1.6 \times 10^{-19} \times 0.75 \times 3 \times 10^{8}$

= 1.062 x 10^{-10} = 1.06 x 10^{-10} N

Helium nuclei:

$F = Bqv = 2.95 \times 2 \times 1.6 \times 10^{-19} \times 0.75 \times 3 \times 10^{8}$

= 2.124 x 10^{-10} = 2.12 x 10^{-10}N

(or 2 times proton's force)

Electron: same as proton: 1.06 x 10^{-10} N

5c. The proton's and Helium nuclei's path must curve downwards (in the same direction) as both are positive. The electron's path must curve upwards as it's negative.

These directions come from the use of the Right Hand Slap Rule: fingers = B-field, thumb = motion of positive particle and out of the palm = Force on moving charge while charge is in B-field.
For electrons we must reverse the direction of the thumb in the right-hand-slap-rule since electrons are negative.

The Helium's path must curve less than the proton because even though He has twice the charge, and twice the force, the He nucleus has about 4 times the mass than a proton so the He's curve will have a larger radius than the proton.

The electron's path must be even more curved (smaller radius) than the proton. The proton and electron have the same magnitude of force as they have equal and opposite charges. But the mass of the electron is much smaller than the mass of the proton (10 orders of magnitude in fact), so the electron's curved path will have a smaller radius than the proton.

6a. Needle in box must be angled to the left (showing a leftwards current through the galvanometer).

6b. $V = BvL = 2.97 \times 0.85 \times 0.39$ = 0.984555V

$$I = \frac{V}{R} = \frac{0.984555}{1.83} = 0.5380\ldots = 0.54\text{A}$$

6c. In this case the conducting rod is being pulled left and is moving across magnetic field lines that are out of the page. The valence electrons in the conducting rod experiment a force to the bottom of the rod.

This direction of electron motion can be found with the right hand slap rule: fingers = B-field, palm = force against motion, thumb = direction of conventional current in moving rod (upwards). Thus the electrons must move the opposite way (downwards).

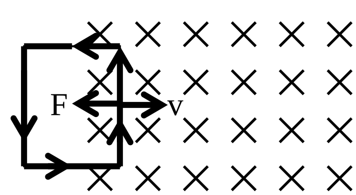
Since the electrons move down the rod, the top of the rod becomes positive. This makes an imbalance of charges in the moving rod which is the induced voltage of V=BvL. The circuit of the rails, wires and galvanometer allow a conventional current to flow anti-clockwise as long as the rod is pulled left. (The electrons flow clockwise.)

7a. $V_{Single} = BvL = 3.9 \times 3.75 \times 0.52 = 7.605$

$V_{Total} = NV_{Single} = 285 \times 7.605$ = 2,167.425V

$$I = \frac{V_{Total}}{R} = \frac{2167.425}{26.3} = 82.41\ldots = 82\text{A}$$

7b.



Anti-clockwise current

7c. (i) as coil enters B-field the leading vertical 52cm edge crosses the B-field lines. When solid conductors are moved across B-field lines the valence electrons inside experience a force and an induced voltage is made in this single 52cm wire. The top becomes + and the bottom becomes -. This charge imbalance is the Voltage induced in the 52cm wire. The conventional current flows form the top around to the bottom in the rest of the loop making an anti-clockwise current. Electrons flow the other way. Since there are 295 turns then each turn induces a voltage of 7.6V making a total of almost 2200V.

7c (ii) as the coil passes through the B-field the leading and lagging 52cm wires each induce a voltage of 7.6V for each turn of wire. But these are in the "same direction" with the + on the top of each 52cm wire and the – on the bottom of each 52cm wire. These voltages cannot create a current as they basically cancel each other out so no current flows.

Alternatively, there is no change in B-field inside the coil, so there is no change in flux. Net voltage is only induced when there is a change in flux.

7c (iii) as the coil exits the B-field the lagging (left) 52cm wire is still crossing B-field lines while the leading (right) wire is not. Now the induced 7.6V per turn can make a clockwise current as the left 52cm wires are the only wires with induced voltage (+ on the top and – on the bottom).

Alternatively, now the B-field inside the coil is shrinking, thus there is a change in flux and an induced voltage so that the current (clockwise) makes a new induced magnetic field to oppose this change in B-field.

7d. The magnetic field could be strengthened or weakened while the coil remains stationary. The coil will have a change in B-field in the area, a change in flux, so will induce a voltage to induce a current to induce a new B-field to oppose the change.

OR the coil could be rotated so that in ¼ turn there are no B-fields going through the area of the coil. The coil then would induce a voltage, current and new B-field to oppose this change. If the coil was continually rotated like this then AC voltage and current would be generated. (Generators sometimes work like this).

Year 12 Physics Waves Review Sheet – ANSWERS

KNOW THE EQUATIONS:

Equation		Symbol's **complete** name And SI unit	Situation where equation is most commonly used (or notes about this equation). Use your own paper
$n_1 \sin\theta_1 = n_2 \sin\theta_2$	n_1	Index of refraction (medium #1) no unit	1. **Snell's Law**: for refraction of light at flat boundary. Angles measured from light ray to NORMAL. Must take inverse sine to find angle. Also used for CRITICAL ANGLE when one angle = 90°
	θ_1	Angle from ray to normal (medium #1) degrees	
	n_2	Index of refraction (medium #2) no unit	
	θ_2	Angle from ray to normal (medium #2) degrees	
$_1n_2 = \frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2} = \frac{n_2}{n_1}$	$_1n_2$	Refractive index (from medium 1 to 2) no unit	2. Also called **Snell's Law**: Used to find relative index between 2 media or used for "deep/shallow" refraction problems.
	$v_{1\text{ or }2}$	Speed of wave (medium 1 or 2) Both in same units	
	$\lambda_{1\text{ or }2}$	wavelength of wave (medium 1 or 2) Both in same units	
	$n_{1\text{ or }2}$	Index of refraction (medium 1 or 2) No units	

$f = \frac{1}{T}$	f	Frequency (Hz)	3. used to get frequency (number of cycles per second) from period (number of seconds per cycle). Can be written as $T = \frac{1}{f}$
	T	Period (s)	
$v = f\lambda$	v	Velocity of wave (ms^{-1})	4. Can be used for any wave. For sound – f and λ must multiply to speed of sound. For light f and λ must multiply to speed of light.
	f	Frequency (Hz)	
	λ	Wavelength (m)	

Be familiar with the COMMON DIAGRAMS and GRAPHS in this unit:

1. Unknowns:
   $?_1$ = normal (imaginary perpendicular)
   $?_2$ = angle of incidence = 50°
   $?_3$ = incident ray

Calculations: Air-ice boundary: using 50°

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$1 \times \sin 50 = 1.31 \sin \theta_2$$

$$\theta_2 = \sin^{-1}\left(\frac{1 \times \sin 50}{1.31}\right) = 35.786\ldots°$$

Ice-diamond boundary:

$$1.31 \times \sin 35.786... = 2.52 \sin \theta_2$$

$$\theta_2 = \sin^{-1}\left(\frac{1.31 \times \sin 35.786...}{2.52}\right) = 17.697\ldots°$$

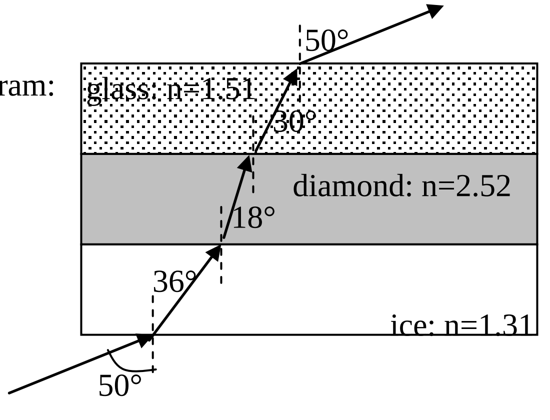
Diamond-Glass boundary:

$$2.52 \times \sin 17.697... = 1.51 \sin \theta_2$$

$$\theta_2 = \sin^{-1}\left(\frac{2.52 \times \sin 17.697...}{1.51}\right) = 30.485\ldots°$$

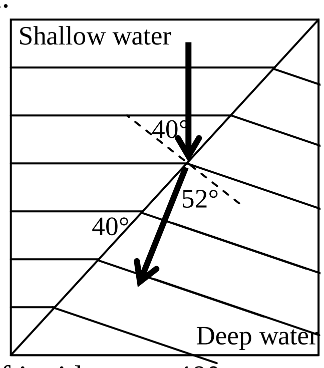
Ray comes out into the air at same angle it entered (50°)

Diagram:



2. **Diagram A:** shows refraction of light from a more optically dense medium to a less optically dense medium (like water into air). The light will increase in speed as it enters the air. The angle to the normal and wavelength will both increase in the air.
   Incident angle must be less than critical angle.
   Diagram B: Shows the critical angle for light rays in the more optically dense medium. Light is refracted at 90° along the boundary (surface).
   Diagram C: Incident angle is larger than critical angle. Diagram shows "total internal reflection" or TIR where light (in more optically dense medium) reflects off of boundary at identical angle staying in the more dense medium.

3. Diagram:



Angle of incidence = 40°

Refractive index of opposite-direction is the inverse of other direction: $\frac{1}{1.22}$ = **0.8196…**

Wavelength in shallow water = $\frac{1.55}{7}$ = 0.221…m

$${}_1n_2 = \frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2} = \frac{n_2}{n_1} \text{ makes: } {}_1n_2 = \frac{\lambda_1}{\lambda_2}$$

and $\lambda_2 = \frac{\lambda_1}{{}_1n_2} = \frac{0.221...}{0.8196...} = 0.270... = \mathbf{0.27m}$

$${}_1n_2 = \frac{\sin\theta_1}{\sin\theta_2} \text{ makes:}$$

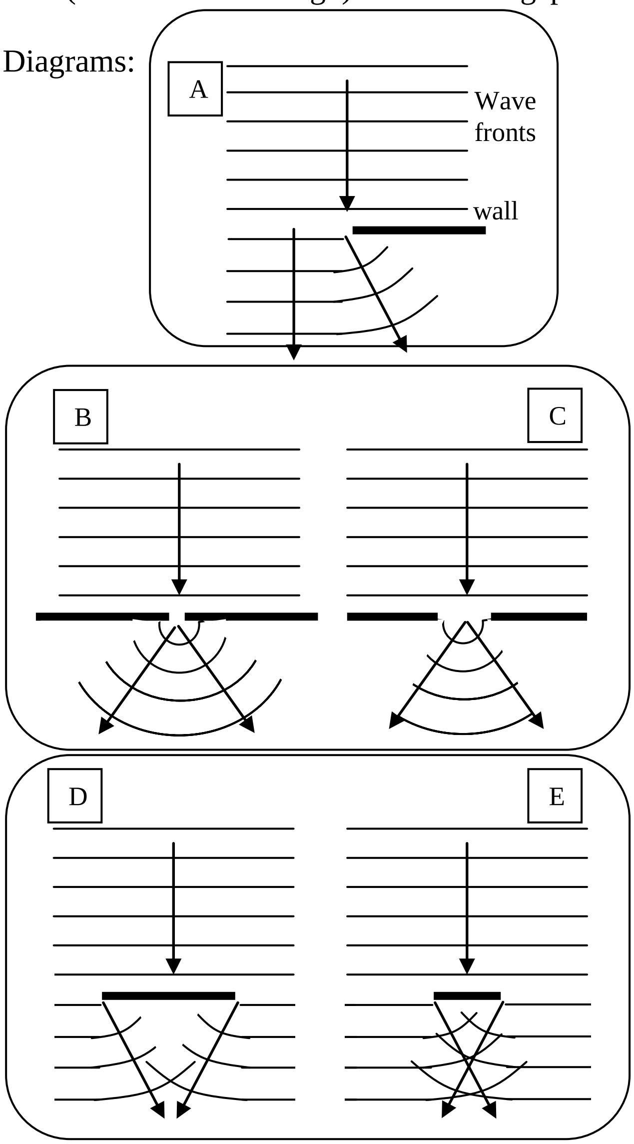
$$\theta_2 = \sin^{-1}\left(\frac{\sin\theta_1}{{}_1n_2}\right) = \sin^{-1}\left(\frac{\sin 40}{0.8196...}\right) = 51.64...$$

= **52°**

4. Principle involved: Diffraction

Definition: the change of direction of waves while they stay in the same medium but go near (or around or through) obstacles or gaps.

Diagrams:



B vs C: The smaller gap (compared to the wavelength) will make the waves diffract at larger angles. So B has less calm-water next to the wall than C.

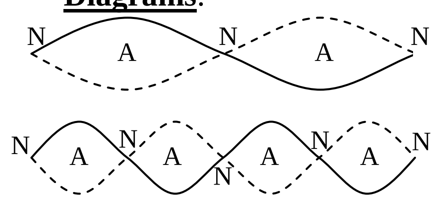
D vs E: the smaller island (E) will have less calm-water just behind it compared to D. The waves will diffract more on smaller islands (or when the barrier is closer to the size of the wavelength).

5. **<u>Explanation:</u>** standing waves are created when 2 waves interfere with each other.

At locations where the 2 waves peak or trough simultaneously (in phase) there is constructive interference (anti-nodes) and the string or water has maximum vibration.

At locations where the 2 waves are out of phase by ½ wave 1 will be peaking while the other is troughing there is destructive interference (nodes) and the string or water will have no vibration.

<u>Diagrams</u>:



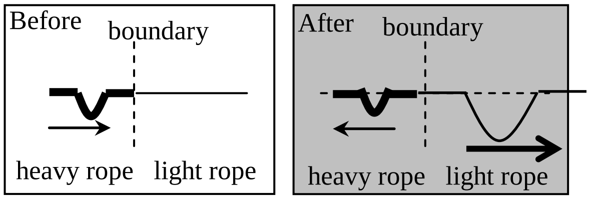
The 1st diagram above is actually for the 2nd possible standing wave. The bottom diagram is for the 4th possible standing wave.
Each standing wave will happen if the rope is wiggled at a multiple of the frequency that made the 1st standing wave.

If the 1st possible standing wave is made at frequency of 25Hz then the 2nd standing wave would happen at 2x25= 50Hz. Then the 3rd at 75Hz and 4th at 100Hz.

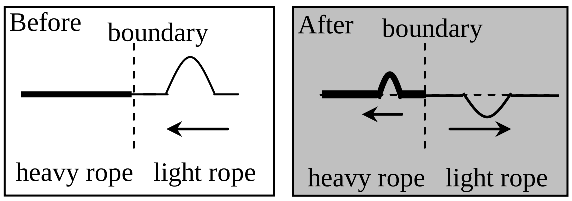
So the 2 diagrams: the top diagram would have ½ the frequency of the bottom diagram.

6. **Diagrams (After for A & B):**

A



B



Explanation of A: The pulse (trough) in the heavy rope partially reflects (in phase) off the boundary at the same speed and width but with a smaller amplitude.

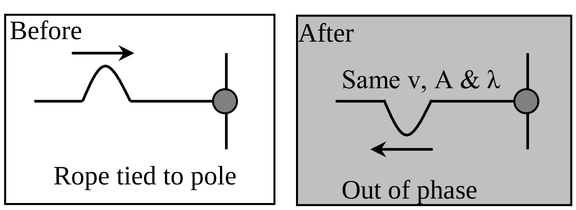
Most of the energy gets transmitted to the light rope making an in-phase pulse (trough) with a faster velocity, higher amplitude and larger width because the light rope takes less force and energy to move than the heavy rope.

Explanation of B: The pulse (peak) in the light rope partially reflects (out of phase) off the boundary at the same speed and width but with a smaller amplitude.

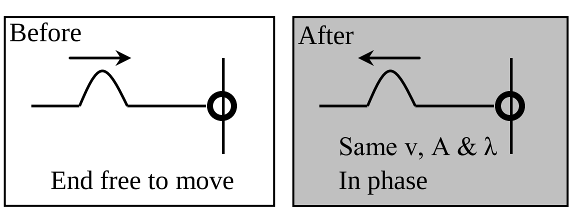
Most of the energy is transmitted into the thick rope to make a pulse (peak) in phase but with smaller velocity, amplitude and width than the light rope. This is because the heavy rope takes more force and energy to move than light rope.

Other diagrams for #6:

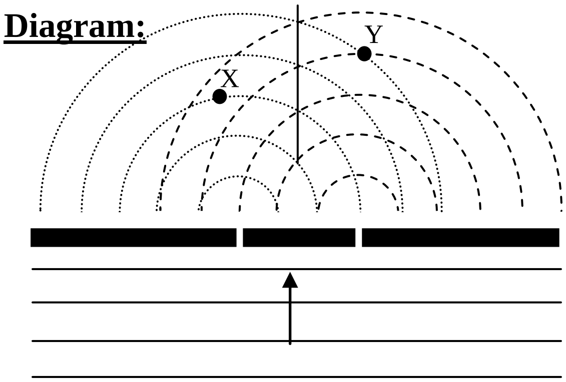
C



D



7. **Diagram:**



Horizontal wavefronts: same λ as ½ circular waves moving at same speed as ½ circular waves grow.

Explanation of dotted lines: each set of dotted lines are waves (crests) that have passed through each gap. Each gap **diffracts** the waves (since the gap is smaller than the wavelength).
The gap can then be considered as a "point source" for the ½ circular waves (centred on the gap).
But the ½ circles do not actually go around 180°. There should be a "shadow" near the barrier of calm water and the ½ circles should be drawn more as arcs slightly less than 180°.

Explanation of X & Y: As the 2 sets of ½ circular waves overlap and occur simultaneously they create an **interference pattern**: locations of constructive interference and destructive interference.
At Y (maximum vibrating water): where the 2 dotted lines cross the 2 waves are in phase, constructively interfering, making for maximum vibration or anti-nodes.
At X (calm water): the 2 waves are out of phase by ½ λ, destructively interfering, making for minimum (or no) vibration or nodes.

8. **Solid lines:** these are locations of constructive interference of the 2 sound waves when both speakers produce the same frequency simultaneously. The central solid line is called the "central maxima" and will be the strongest antinodal line (loud sound). The 2 waves occur in phase and constructively interfere.

   The solid line to the left or right of the central maxima are more antinodal lines. This time there is a **path difference of one complete wavelength** (from each speaker to a spot on that line) so that the waves occur again in phase and constructively interfere to make for loud spots.

   There is a further set of solid lines (outer lines) that show another set of antinodal lines but with 2 λ of path difference (from each speaker to a spot on those lines).

   Dotted lines: ½ way between each antinodal line is a "nodal line" where the 2 sound waves are occurring ½ λ out of phase and destructively interfering to make a quiet area.

The 1st set of dotted lines (next to the central maxima) are where the waves have exactly **½ λ of path difference** from each speaker to a spot on that dotted line.
The 2nd set of dotted lines have a 1 ½ λ path difference.

Person walking from A to B would hear the speaker's single frequency change from loud to quiet to loud repeatedly as they walk through antinodal and nodal areas.
$?_3$ = loud. $?_2$ = quiet. $?_1$ = loudest.
There are 5 loud areas between A & B and 4 quiet areas.

Note: If both of the speakers made a different frequency then the locations of the antinodal and nodal lines would shift because the λ would be different (speed of sound = constant).

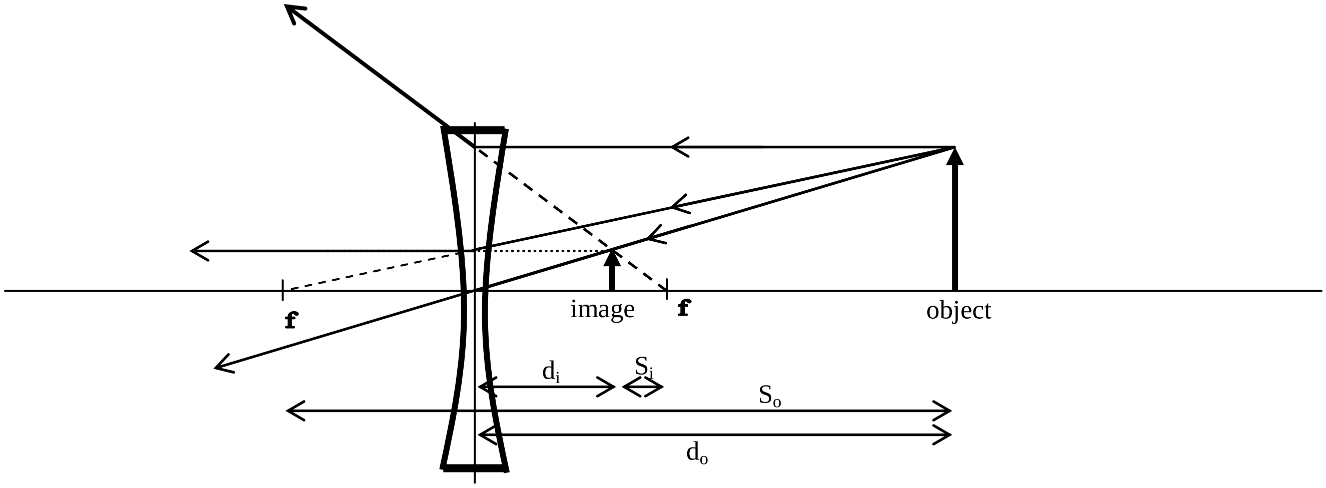
Higher pitch sounds (smaller λ) will have antinodal lines closer together and lower pitch sounds (larger λ).

Year 12 Physics Lens & Mirror Review Sheet – ANSWERS

KNOW THE EQUATIONS:

Equation		Symbol's **complete** name And SI unit	Situation where equation is most commonly used (or notes about this equation). Use your own paper
$\frac{1}{f}=\frac{1}{d_o}+\frac{1}{d_i}$	f	Focal length (cm) or (mm) or (m)	1. All 3 must have same units. Focal length (f) negative for convex MIRROR and concave LENS. d_i will be negative for VIRTUAL images. Must remember to INVERSE before getting final answer. Called "**Descartes Formula**"
	d_o	Distance from object to lens/mirror (cm) or (mm) or (m)	
	d_i	Distance from image to lens/mirror (cm) or (mm) or (m)	
$m=\frac{d_i}{d_o}=\frac{h_i}{h_o}=\frac{f}{S_0}=\frac{S_i}{f}$	m	Magnification (no units)	2. Called "**Newton's Formula**". No negatives for this formula. Can have 2 more fractions in same formula. S's can be to "near" or "far" focal point in lenses. Convex lens: S_o to "near", S_i to "far". Concave lens: S_o to "far", S_i to "near
	h_i	Height of object (cm) (mm) or (m)	
	h_o	Height of image (cm) (mm) or (m)	
	S_o	Distance from object to focal point (cm) or (mm) or (m)	
	S_i	Distance from image to focal point (cm) or (mm) or (m)	

Be familiar with the COMMON DIAGRAMS and GRAPHS in this unit:



1. a) Names: concave lens or diverging lens

b) diagram done above

c) calculations: need to use negative f

f = 45/2 = - 22.5

$$\frac{1}{f}=\frac{1}{d_o}+\frac{1}{d_i} \text{ makes: } \frac{1}{d_i}=\frac{1}{f}-\frac{1}{d_o}=\frac{1}{-22.5}-\frac{1}{50}$$

d_i = -15.517… = 15.5cm

$$m=\frac{d_i}{d_o}=\frac{15.517...}{50} = 0.310… = 0.31$$

S_i = image to near focus in concave lens

$S_i = f – d_i$ = 22.5 – 15.517… = 6.98cm

S_o = object to far focus in concave lens

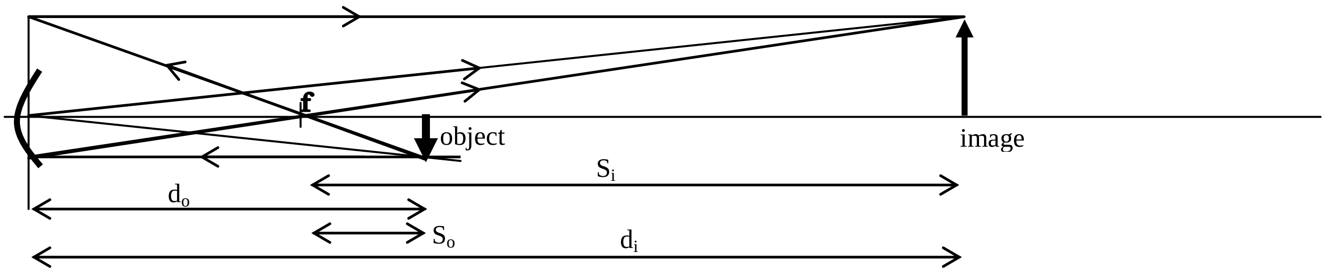
$S_o = f + d_o$ = 22.5 + 50 = 72.5cm

d) labels on diagram above

e) Nature of image: virtual, diminished, upright

f) As the object moves right (further away) the image will get even smaller, but stay virtual and upright. The image will get closer to the near focal point.

2 a)



b) calculations

$$\frac{1}{f}=\frac{1}{d_o}+\frac{1}{d_i} \text{ makes: } \frac{1}{d_o}=\frac{1}{f}-\frac{1}{d_i}=\frac{1}{42}-\frac{1}{120}$$

$$m=\frac{d_i}{d_o}=\frac{120}{64.615...} = 1.857… = 1.9$$

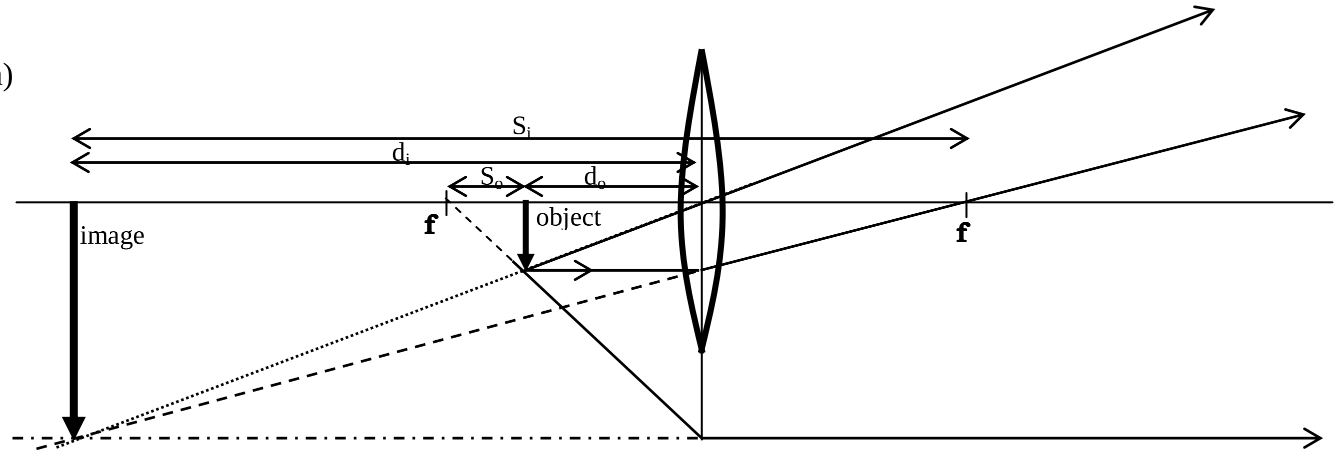
d_o = 64.615… = 64.6cm

c) on diagram above

d) If the object was moved "a bit" to the left the image would move quickly off to the right (off the page). The closer the object is to the focal point, the larger the image gets and the farther from the mirror the image goes. The image will still be real, inverted and magnified as long as the object does not get to f.

e) If the object was moved "more than a bit" to the left then the object would be on the other side of f. Then there would be a virtual, upright and magnified image behind the mirror.

3 a)



b) calculations:

$S_o = 6$, $h_o = 8.5$, $f = 18$

From diagram: $d_o = f – S_o = 18 – 6 = 12$cm

$$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{1}{18} - \frac{1}{12}$$ gives d_i = -36cm

From diagram: S_i = image to far focus = $d_i + f$ = 36 + 18 = 54cm

$$m = \frac{d_i}{d_o} = \frac{36}{12} = 3$$

c) on diagram

d) If object moves "a bit to the right" the image would move to the right. The image would remain virtual, magnified & upright (as it is now) but would get smaller (less magnified) as d_i get smaller. d_i would still be larger than d_o.

e) If object moved 6cm to left then $d_o = f$. This would have a ray diagram with parallel lines and no image would be formed.

f) To get an image the same height as the object (8.5cm) then magnification needs to = 1. The only place the object can be placed is on either c (centre of curvature). The image would be real, inverted and the same size located on the other c. So d_o = 36cm would make this happen.

4a)

Convex mirror needs –f AND image always virtual so $–d_i$

$f = –8$ $d_i = –5$

$$\frac{1}{d_o} = \frac{1}{f} - \frac{1}{d_i} = \frac{1}{-8} - \frac{1}{-5}$$ gives d_o = 13.333…cm

$$m = \frac{d_i}{d_o} = \frac{5}{13.333...} = 0.375$$

$m = \frac{f}{S_0}$ makes: $S_o = \frac{f}{m} = \frac{8}{0.375} = 21.333…$cm

$m = \frac{S_i}{f}$ makes: $S_i = mf = 0.375 \times 8 = 3$cm

4b) concave mirror needs +f (f = 8) AND image is behind mirror: so still virtual: $d_i = –5$

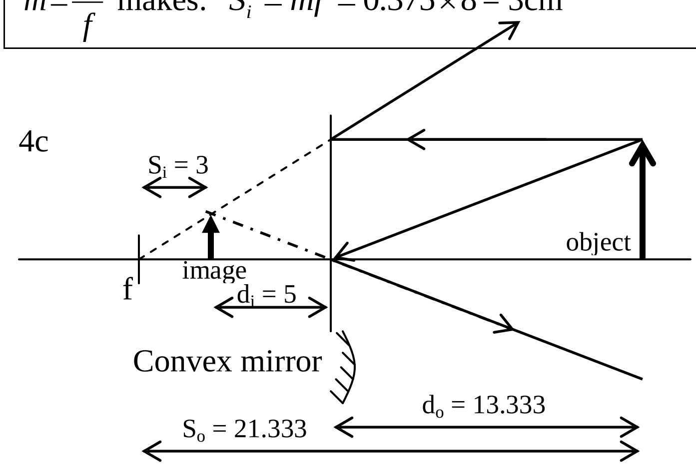
$$\frac{1}{d_o} = \frac{1}{f} - \frac{1}{d_i} = \frac{1}{8} - \frac{1}{-5}$$ gives d_o = 3.0769…cm

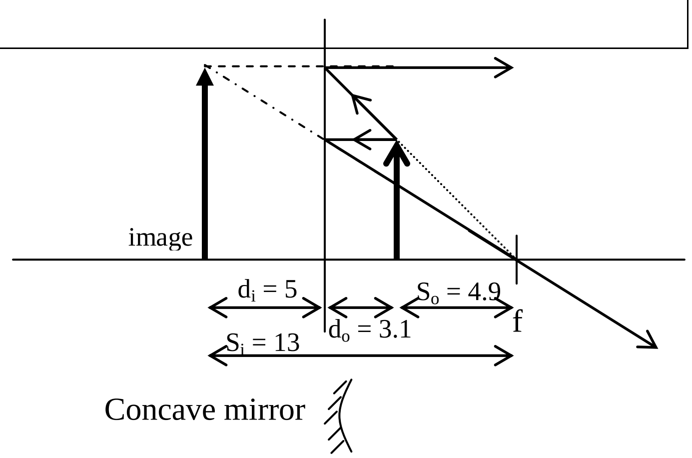
$$m = \frac{d_i}{d_o} = \frac{5}{3.0769...} = 1.625$$

$$S_o = \frac{f}{m} = \frac{8}{1.625} = 4.923…\text{cm}$$

$S_i = mf = 1.625 \times 8 = 13$cm

4c



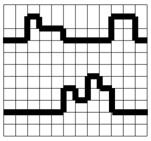


4d) **For convex mirror:** if object moved farther away the image remains virtual, upright & diminished but moves slightly to the right to be closer to f and is slightly smaller.
For concave mirror: if object is moved 'just a bit" to the right (farther away) but still with do < f, the image will remain virtual, magnified & upright but the image moves quickly to the right to be even larger and farther from the mirror.

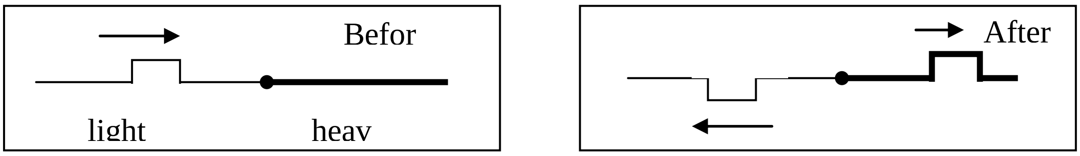
4e) **TRICK QUESTION**
For concave mirror, the only location for object to give m=1 (image same height) is for object to be placed on c. Image will also be on c: real, inverted & same size – right underneath object.

For convex mirror it is IMPOSSIBLE to get m=1 (image same height) no matter where object is placed. Image is always diminished.

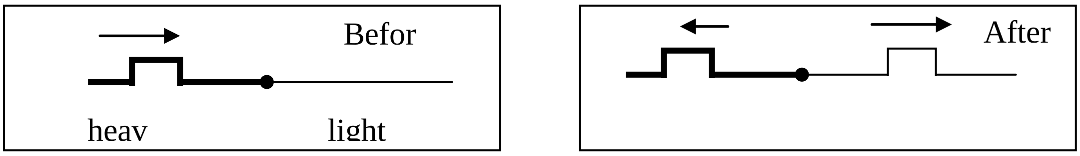
Pulse Superposition & Thick-Thin Pulses Revision Questions

ONE (a)	An interference pattern is a pattern of wave maxima and minima that appear to stay in one place. The positions of these maxima and minimum have a regular arrangement with a mathematical relationship related to the wavelength of the waves. The pattern happens when two wave trains of the same frequency and amplitude pass through each other in the same medium. Crest overlap with crest creates large crests and crest with trough cancel out.	The pattern formed by the overlap of two sets of waves reinforcing and cancelling out.	PLUS the mention of reasons for maxima and minima such as crest/trough cancellation, etc. The explanation shows understanding of the main ideas.	PLUS minimal irrelevancies. The explanation shows clear understanding of all the necessary conditions for interference.
(b)		Pulses advanced correct number of squares relative to original positions	Correct addition of amplitudes to give correct shape	

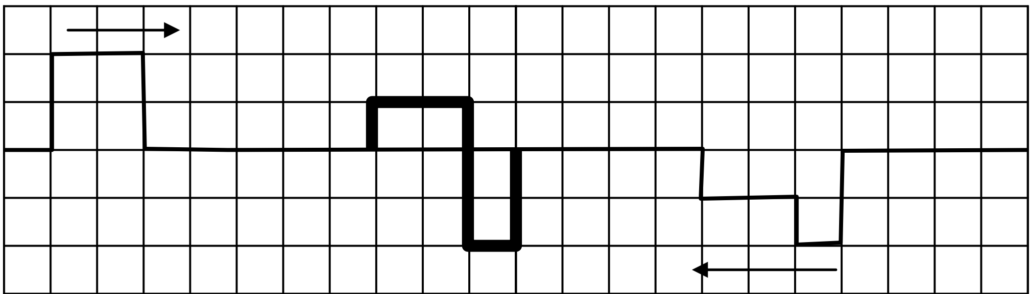
2. (a)



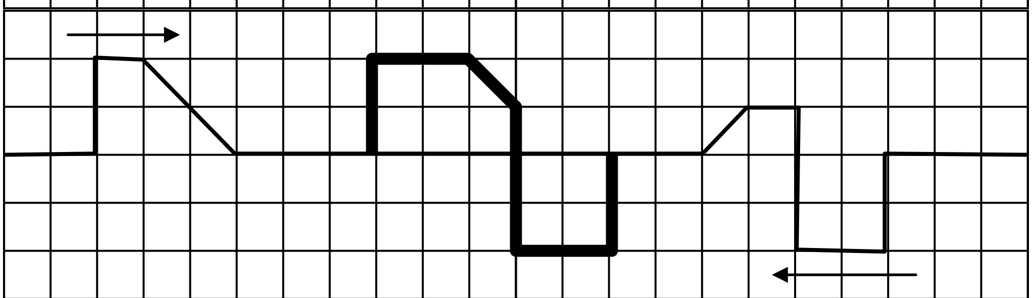
(b)

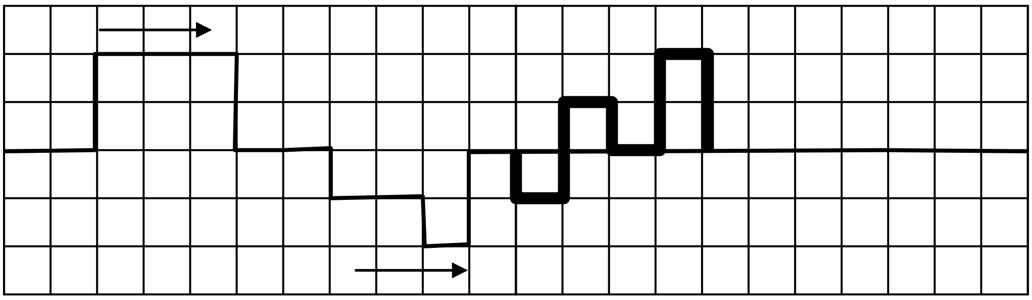


3a.

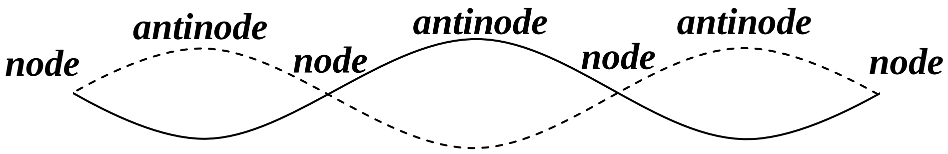


3b.



3c. 

4. **_In order:_** ***reflected opposite standing displacement nodes maximum antinodes.***

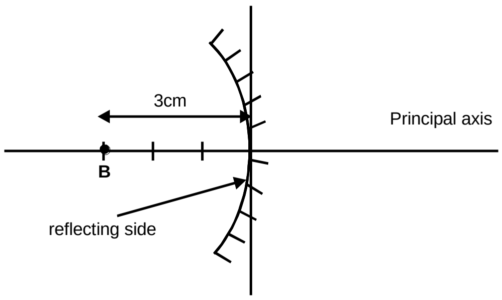
5a. 

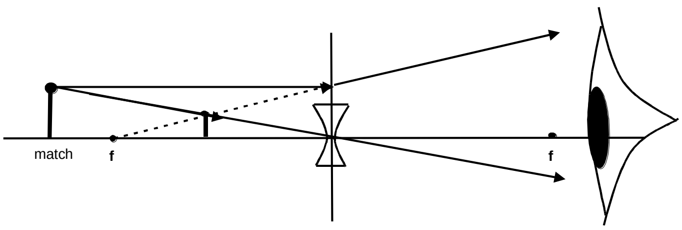
5b. (i) ***1/3 = 33.3 cm*** (ii) ***v = 350 x 0.333 = 117 ms^{-1}***

5c. (i) ***Violin, guitar, piano*** (ii) ***Flute, trumpet***

5d. **_0.5 s_**

Mirrors & Lenses AND Refraction Revision Questions

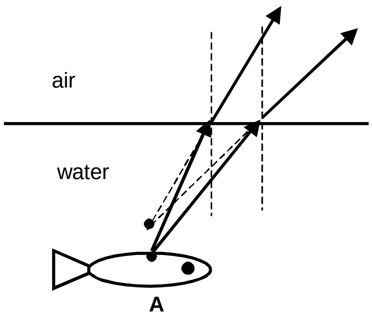
One (a)	f = c/2 3 = c/2 c = 6 cm	Correct answer.		
(b)		**B** correctly placed.		
(c)	**All** the light rays from the focal point that strike the mirror **will be reflected parallel** to principal axis.		Correct explanation.	



(d)	Rays correctly drawn.	One ray correctly drawn.	Both rays correctly drawn with arrows.	
(e)	Dotted line drawn, and image placed at intersection, correctly.	Either the line is correctly drawn or image is correctly placed.	Both done correctly.	

(f)	Virtual, upright and diminished	Two correct properties stated.		
(g)	$1/f = 1/d_o + 1/d_i$ $1/(-0.42) = 1/(4.1) + 1/d_i$ $1/(-0.42) – 1/(4.1) = 1/(4.1) + 1/d_i – 1/(4.1)$ $- 2.62.. = 1/d_i$ $- 0.380… = d_i$ $- 0.38m = d_i$	***f* incorrectly substituted as +0.42 m resulting in an answer of +0.47m.**	Correct substitution, working and answer.	
(h)	$m = \frac{d_i}{d_o} = \frac{-0.380...}{4.1}$ = - 0.0929… = - 0.09	Correct substitution, working and answer. (Allow for consequential error from (g).)		

(i)	$m = \frac{d_i}{d_o}$ and m = -0.5 So $d_i = -0.5\ d_o$ $1/f = 1/d_o + 1/d_i$ $1/(-0.42) = 1/d_o + 1/(-0.5\ d_o)$ $(-0.5)/(-0.42) = (-0.5)/d_o + 1/d_o$ $0.5/0.42 = 0.5/d_o$ *So d_o = 0.42 cm*	Correctly expresses d_i in terms of d_o.	Correct method and substitution, answer wrong due to wrong working.	Correct substitution, working and answer.

Two (a)	 		Diagram correct.	
(b)	The rays of light striking the eye (when projected back – see dotted lines) seem to be coming from a point **above** the actual position of point A on the fish. This happens because the eyes “see” in straight lines.		***Mentions that eyes see in straight lines.***	Explanation is clear, concise and accurate as given.
(c)	The velocity of the water waves increases as it moves from the shallow region to the deeper region causing the wavelength to increase as well, but the frequency remains the same.	Mention that velocity increases.	Correct explanation involves wavelength increase and constant frequency.	
(d)	$v = \lambda f$ = (0.21) x (2.2) = 0.462… = 0.46 ms^{-1}	Correct working and answer.		

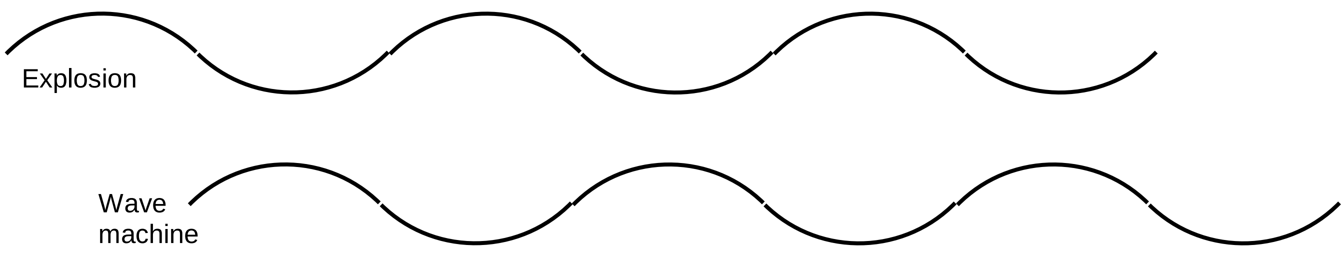
3 (a)	$\theta_1 = 90-43 = 47^{\circ}$ $n_1\sin\theta_1 = n_2\sin\theta_2$ $(1.51)\sin(47^{\circ}) = (1.33)\sin\theta_2$ $(1.05)\sin(43^{\circ}) / (1.33) = (1.33)\sin\theta_2 / (1.33)$ $0.83.. = \sin\theta_2$ $56.1\ldots = \theta_2$ $\theta_{2=} 56^{\circ}$	Correct formula and substitution but using $\theta_1 = 43$ and leading to an answer of 50.7° OR Correct calculation of θ_1.	Correct substitution, correct working and answer.	
(b)	$n_{glass}\sin\theta_{critical} = n_{water}\sin(90)$ $(1.51)\sin\theta_{critical} = (1.33) \times 1$ $\sin\theta_{critical} = 0.88\ldots$ $\theta_{critical} = 61.7^{o} = 62^{o}$		Correct substitution.	Correct working and answer.
(c)	$n_2/ n_{1=} v_1/v_2$ $1.33/1.51 = v_1/2.26 \times 10^8$ $v_1 = 1.99 \times 10^{8}\,ms^{-1}$ $v_1 = f\lambda_1$ $1.99 \times 10^{8} = 5.64 \times 10^{14} \times \lambda_1$ $\lambda_1 = 3.0 \times 10^{-7}$ m		Correct method and substitution, answer wrong due to wrong working	Correct method and substitution, answer

4 (a)	Student draws a circular reflected wave.		
(b)	The wave train direction is bent away from the normal.	The wave train direction is bent away from the normal AND the wavelength is increased.	The wave train direction is bent away from the normal AND the wavelength is increased AND constant.
(c)	The wavelength increases because the wave speeds up in the deeper region.	When a wave front enters the deeper region it speeds up and so travels a greater distance in the same time that a wave front in the shallow region travels. This increases the distance between successive crests compared to their separation in the shallow region.	
(d)	Correct process but maths wrong.	vshallow / vdeep = refractive index vdeep = 0.75/0.80 = 0.94 ms^{-1}	

5 (a)	Correct approach but maths wrong.	$n_1\sin\theta_1 = n2\sin\theta_2$ $1.36 \times \sin 33 = 1.54 \times \sin\theta_2$ $\sin\theta_2 = 0.481$ Angle of refraction = 29^{o}	
(b)	Angles shown correctly but student does not attempt to show that emerging ray is parallel with the original ray.	Sketch shows that ray emerges from the second face of the crystal parallel with the original ray. Also the angles are shown as 29^{o}, 29^{o} and 33^{o} respectively.	
(c)	Rearrangement error but process right.	nalcohol = cvacuum/calcohol calcohol = 3×10^{8} / 1.36 = 2.2x108 ms^{-1}	
(d)	One of the conditions correctly given.	The ray of light must be passing from a more dense to a less dense medium at an angle of incidence greater than the critical angle.	
(e)	Attempts to use Snells law and realises that the incident angle is C OR the refracted angle is 90^{o}	Recognition that incident angle is C AND the refracted angle is 90o but incorrect substitution or rearrangement of Snell's law.	$n_1\sin\theta_1 = n_2\sin\theta_2$ 1.54 x sin C = 1.36 x sin90 sinC = 0.883 Crit angle = 62^{o}
(f)	The boy would still see the light as green (without reasons)	The light is seen as green because its frequency is unchanged by change of medium.	Sees green light. Although the light slows down and the wavelength changes the frequency remains the same. So when the light enters the boys eye its speed and wavelength become that which is characteristic for that frequency and which the boy always sees as green.

Diffraction & Interference Revision Questions - ANSWERS

One (a)	Light flash	light flash		
(b)	Light travels faster /light is electromagnetic/ light is transverse / light requires no medium / sound travels slower / sound is mechanical/ sound is longitudinal/ sound requires a medium.	any TWO correct statements.		
(c)	t = 3.0s, v = 330 m/s d = vt d = 330 x 3.0 = 990 m	Correct substitution and answer		
(d)	$\lambda = v / f$ = 330 / 160 = 2.1 m	Correct substitution and answer		
(e)	T = 1/f = 1/160 = 0.00625 s/ 6.25 x 10^{-3}s/ 6.25 ms	Correct substitution and answer		
(f)	Diffraction	Diffraction		
(g)	Sound has a much longer wavelength: so it diffracts more.	*Sound has a much longer wavelength / sound diffracts more.*	Sound has a much longer wavelength: so it diffracts more.	
TWO (a)	The machine produces sound of the same wavelength (or frequency) that is out of phase by ½ a cycle from the original sound. Destructive interference cancels the original sound if the amplitudes are similar. Or diagram below	*Diagram only*	*correct explanation for phase / destructive interference*	correct explanation for phase / destructive interference: and amplitude
(b)	Wave interference The waves emitted from the 2 rockets interfere resulting in superposition. This superposition results in constructive (loud) and destructive (soft) interference of sound waves. (diagrams are optional)		*Answer shows **some** understanding of the phenomenon of interference between 2- point sources*	Answer shows a **clear** under-standing of the phenomenon of interference between 2-point sources.



Three (a)	Wave interference	Correct term given		
(b)	The loud areas are caused by wave fronts arriving in phase and forming constructive interference. The soft areas are caused by wave fronts arriving out of phase and forming destructive interference. (Diagrams are optional)		Answer shows **some** understanding of the phenomenon of interference between 2- point sources	Answer shows a **clear** understanding of the phenomenon of interference between 2- point sources.
(c)	$f = 1/T = 1/ 5.0 \times 10^4 = 2000$Hz $\lambda = v/f = 330/2000$ $= 1.65$ m	Correct calculation of frequency.	Correct working and answer.	
(d)	The 100 Hz sound diffracts the most. The amount of diffraction is most pronounced when the wavelength ($\lambda = 3.3$ m) is approximately the same as the slit width (3 m) created by the open doorway.			Correct answer.

Four (a)	Diffraction		
(b)	Drawing shows a wave train approaching the bay and passing through the entrance. The wave train carries on with little diffraction. Ie no waves spread out to reach the boat.	Correct diagram that shows <u>short</u> wavelength waves (wavelength about one quarter the width of the entrance gap to the bay) plus comment that the waves will not affect the boat because they are not diffracted very much, if at all.	Merit plus explanation that links the lack of diffraction to the fact that the wavelength of the waves is smaller than the entrance gap to the bay.
(c)		Correct process but failure to work out frequency correctly.	$f = 9/60 = 0.15$ Hz $v = f\lambda = 0.15 \times 4.2 = 0.63$ ms^{-1}
(d) (i)	Nodes at ends and crossing points. Antinodes at maxima.		
(d) (ii)	Wavelength = 1.5/1.5 = 1m		
(e)	Destructive interference		

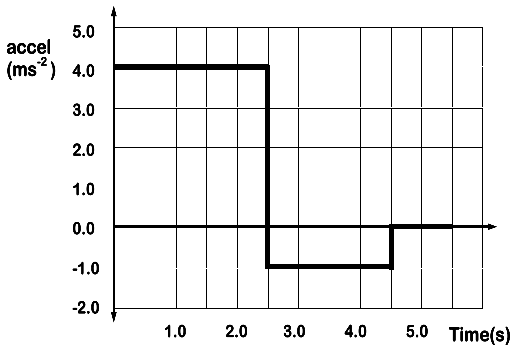
Linear Mechanics AND Energy Revision Question ANSWERS

ONE (a)	$\Delta E_P = mgh = 0.41 \times 10 \times 5.0 = 20.5$ J	Correct formula substitution, working		
(b)	$0.5\ mv^2 = mgh$ $v = \sqrt{2gh}$ $= \sqrt{2 \times 10 \times 5.0}$ □□□□ $= \sqrt{100} =$ 10 m/s	***Equated $E_k = E_p$ and steps are correct but wrong answer***	Correct working and answer.	
(c)	The gain in kinetic energy of the soccer ball is equal to its loss in gravitational potential energy as its total energy is conserved. There is no air resistance acting on the ball	Statement that gain in kinetic energy = loss in gravitational potential energy.	Statement that gain in kinetic energy = loss in gravitational potential energy and energy is conserved.	Explanation is clear, concise and accurate.
(d)	Ratio of speed squared = ratio of kinetic energies = 8.2/4.1 = 2.0 $v_2/v_1 = \sqrt{2.0}$ or 1.4			Correct reasoning and correct answer.

TWO (a)	a = $(v_f - v_i)/t$ = 8.6/5.5 = 1.6 ms^{-2}		
(b)	d = $v_i t$ + $0.5at^2$ = (1.4x5.5) + (0.5x1.6x5.5^2) = 7.7 + 24.2 = 32 m		
(c)	One of the steps correctly attempted.	Not in standard form or not to 2 sig. figs but process correct.	F = ma = 1080 x 1.6 = 1728N W = Fd = 1728 x 32 = 55296 = 5.5 x 10^4 J
(d)	Answer mentions friction or drag but does not specify that work has to be done against it.	The engine must provide sufficient energy to accelerate the boat as well as do work against the frictional and drag forces which oppose its motion.	

Three (a)	$d = v_i t + \frac{1}{2}at^2$ $19.2m = 0 + \frac{1}{2} \times a \times 4.0s^2$ $\therefore a = \frac{2 \times 19.2m}{4.0s^2} = 2.4ms^{-2}$		Correct substitution, rearrangement and calculation.	
(b)	$v_f = v_i + at = 0 + 2.4ms^{-2} \times 4.0s$ $v_f = 9.6ms^{-1}$ OR $v_f^2 = v_i^2 + 2ad = 0 + 2 \times 2.4ms^{-2} \times 4.0s$ $v_f^2 = 92.16m^2s^{-2} \therefore v_f = 9.6ms^{-1}$	Correct substitution and calculation		
(c)	Time remaining = 12.8s – 4.0s = 8.8s. Distance remaining = 100 – 19.2m = 80.8m $v = \frac{d}{t} = \frac{80.8m}{8.8s} = 9.18ms^{-1} = (9.2ms^{-1})$		Correct substitution, inference and calculation.	
(d)	Calc a first. $a = \frac{v_f - v_i}{t} = \frac{0 - 8.8ms^{-1}}{6.0s} = -1.466$ then calc d. $d = v_i t + \frac{1}{2}at^2 = 8.8 \times 6.0 + \frac{1}{2}(-1.466) \times 6.0^2$ $d = 26.4m$	*Consequential correct d if used incorrect a.*	*correct calc of a*	Correct substitution, rearrangement and calculation.

Four (a)	Ben's Acceleration = Gradient of vel vs t $a = \frac{\Delta v}{\Delta t} = \frac{10 - 0ms^{-1}}{2.5 - 0s} = 4.0ms^{-2}$	Correct substitution and calculation.		
(b)	Distance = area under graph = triangle $d = \frac{1}{2} \times 10ms^{-1} \times 2.5s = 12.5m$	Correct substitution and calculation.		
(c)	Barbara moved at 8.0ms^{-1} for 2.5s = 20m. Ben moved 12.5m to be in the same place at t=2.5s. So Ben started 7.5m (20–12.5m) in front of Barbara, at t=0.0s		Correct reasoning and calculation.	

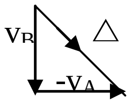
(d)	$v_{avg} = \frac{d}{t}$ and distance = total area $d = 8.0ms^{-1} \times 2.5s + \frac{1}{2} 8.0ms^{-1} \times (5.5s - 2.5s)$ $d = 20m + 12m = 32m$ so $v_{avg} = \frac{32m}{5.5s} = 5.818ms^{-1} = (5.8ms^{-1})$		Correct reasoning and calculation.	
(e)			*$a_i = 4.0ms^{-2}$ (allow consequential from 4(a))* *and* *$a_f = +1.0ms^{-2}$.*	Correct graph

Five (a)	Elastic potential Energy		
(b)	E_p = mgh = 65 x 10 x 3.6 = **2340J**		
(c)			$\Delta E_p = \Delta E_k$ 2340 = ½ $65v^2$ v = 8.48528… **≈ 8.48ms^{-1}**
(d)		Kinetic Energy he left the tramp with was completely transferred to gravitational potential energy. Friction turning kinetic energy to heat small enough to be ignored.	

Circles AND Springs Revision Question ANSWERS

ONE (a)	The Moon has an acceleration because its velocity is continually changing as its direction is continually changing.		Correct explanation	
(b)	$v = \Delta d/\Delta t = 2\pi r/T$ $= 2\pi \times 3.84 \times 10^8/2.36 \times 10^6$ $= 2.36 \times 10^6 = 1.02 \times 10^3$ m s^{-1}.		Correct formula substitution, workng	
(c)	$a_c = v^2/r$ $= (1.0223488 \times 10^3)^2/3.84 \times 10^8$ $= 2.72 \times 10^{-3}$ m s^{-2}. F= ma $= 7.3 \times 10^{22} \times 2.72 \times 10^{-3} = 1.96 \times 10^{20}$ N OR using $F = mv^2/r$	Correct working and answer for the acceleration.	Correct working and answer.	
(d)	Towards the centre	Correct direction.		

two (a)	Acceleration indicated to be along the line of the ski rope.		
(b)	The centripetal force is provided by the <u>tension force</u> in the ski rope.		

(c)		Correct approach using the two necessary equations but incorrect answer. OR Correct first step involving the rearrangement of $v = 2\pi r/T$ equation to get the radius.	$v = 2\pi r/T$ $r = vT/2\pi$ $= 14 \times 40/2\pi$ $= 89$ m $F = mv^2/r$ $= (58 \times 14^2)/89 = 130$ N
(d)	Arrows drawn correctly as tangents to the circle.		
(e)		Failure to reverse the direction of v_A in the vector diagram so bearing value wrong. OR Correct calculation of the magnitude and direction but the bearing not calculated or stated incorrectly.	$\triangle v = v_B - v_A = v_B + (-v_A)$ $\triangle v = \sqrt{(14^2 + 14^2)} = 20$ ms^{-1} Isosceles right angle triangle means that the <u>bearing will be 45°</u>

THREE

a. ***How stiff or stretchy the spring is. A stiff spring has a large spring constant.***

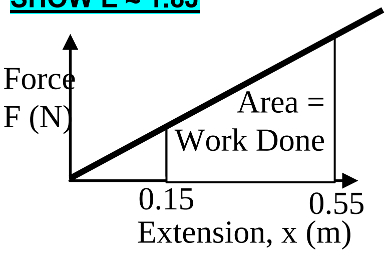
b. ***(i) Hang the spring from a support and then attach a range of different weights to it.***
(ii) For each weight force, record the extension of the spring.
(iii) Graph results, plotting the weight force on the y-axis and the extension on the x-axis.
(iv) Measure the gradient of the graph line. This is the value of "k".

c. $x = F/x = 1200/2 \times 10^5 = 0.006$ m (6 mm)

d. ***(i)*** $k = F/x = 25/70 = 0.36$ Nm^{-1}
(ii) $E_P = \frac{1}{2}kx^2 = 0.5 \times 36 \times 0.35^2 = 2.21$ J
(iii) Area

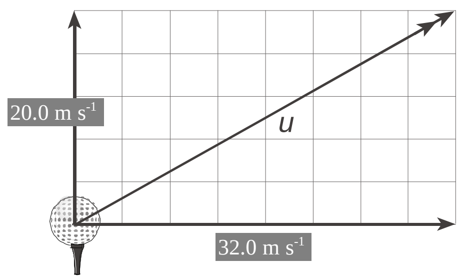
e. ***(i)*** $F = mg = 1.2 \times 10 = 12$ N
(ii) $k = F/x = 12/0.08 = 150$ Nm^{-1}
(iii) $E_P = \frac{1}{2}kx^2 = 0.5 \times 150 \times 0.08^2 = 0.48$ J

FOUR (a)	Spring Constant Large value = stiff spring Small value = weak spring	Spring constant AND one of 2 value descriptions	All 3 answers	
(b)	SHOW: k = 13 $mg = kx$ gives: $k = \frac{mg}{x} = \frac{0.79 \times 10}{2.45 - 1.85} =$ **13.1666… ≈ 13**		Uses equation of $mg = kx$ correctly to SHOW answer including x = 2.45 – 1.85	
unit	**N/m or Nm^{-1}**	Correct unit		
(c)	New x: $x = \frac{mg}{k} = \frac{0.915 \times 10}{13.1666...} =$ 0.694936708… $E = \frac{1}{2}kx^2$ $\frac{1}{2} \times 13.166... \times 0.694...^2 =$ 3.1793… ≈ **3.2J** **(using 13Nm^{-1} gives same rounded answer of 3.2J with x of 0.70…m)**	Gets new extension correctly	Uses $x = \frac{mg}{k}$ and $E = \frac{1}{2}kx^2$	Correct Answer

d	**SHOW E ≈ 1.8J**  The two x's come from 2.00 – 1.85 = 0.15m and 2.4 – 1.85 = 0.55m $E = \frac{1}{2}kx^2$ with x = 0.15 E = 0.1481… (or 0.14625 with k = 13) $E = \frac{1}{2}kx^2$ with x = 0.55 E = 1.99145… (or 1.96625 with k = 13) Difference ≈ 1.8J	Either correctly labelled GRAPH OR correct x's and E_p's	Correct graph AND correct x's and E_P's	Fully labelled graph with AREA = WORK DONE AND correct math showing difference in E_P ≈ 1.8J

Momentum AND Projectiles Revision Question ANSWERS

One (a)	p = mv = 1080x 4.3 = 4644 kgms^{-1}		
(b)	△p = m△v = 180x1.3 = 234 kgms^{-1}		
(c)	Realisation that total momentum is conserved in the collision.	Change in speed calculated but not converted into final speed.	△p = 234 = m△v △v = 234/1080 = 0.22 v(final) = 4.3 – 0.22 = 4.1 ms^{-1}
(d)	Attempts to compare KE values before and after the collision but not able to complete calculation correctly.	Does not take into account significant figures and concludes that Energy is lost therefore the collision is not elastic.	KE before =(0.5x1080x4.3^2) + (0.5x180x3.5^2) = 9985 + 1103 = 11188 J KE after =(0.5x1080x4.1^2)+ (0.5x180x4.8^2) = 9077 + 2074 = 11150 J If significant figures are taken into account both the energy before and after are 1.1x10^4 J and so the collision is elastic.

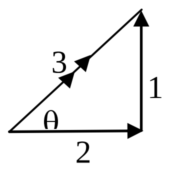
TWO (a)	A projectile path is the movement of an object under the action of gravity only.	Correct description.		
(b)	 	Correct size.	Correct size with arrows for correct direction.	

(c)	$u^2 = 20^2 + 32^2$ $\Rightarrow u = 37.735925 = 38\ m\ s^{-1}$ $\tan\theta = 20/32 \Rightarrow \theta = 32^0$.		Correct working and answer for size.	Correct working and answer for size and direction.
(d)	The ball is moving with a *constant acceleration acting vertically downwards* (constantly decelerating upwards). The golf ball's acceleration is due to gravity. The golf ball's weight is the unbalanced force acting on it.	Statement that the acceleration is constant.	Achieved plus statement that the acceleration is directed vertically downwards.	Explanation is clear, concise and accurate as given.
(e)	$v_f = v_i + at$ $\Rightarrow 0 = 20 - 10t$ $\Rightarrow t = 2.0$ s	Correct formula substitution, working		
(f)	$v_f^{\ 2} = v_i^{\ 2} + 2ad$ $\Rightarrow 0^2 = 20^2 + 2 \times (-10)H$ $\Rightarrow H = 20$ m	Correct substitution of data.	Correct working and answer.	
(g)	Motion is *constant velocity (speed and direction)* as there is no unbalanced force acting on the golf ball in the horizontal direction.	Statement that the velocity is constant.		Explanation is clear, concise and accurate.
(h)	$v = \Delta d / \Delta t$ $\Rightarrow 32 = R/2t$ where $\Delta t = 2t$ $\Rightarrow R = 2 \times 32 \times 2 = 138$m	***t is not doubled and has an answer of 69m***	Correct answer.	
Three (a)	Zero	Correct answer.		
(b)	Zero. The rifle and bullet may be treated as an isolated system with no external force acting on it. The total momentum is conserved.	Correct value.	Statement implying that the total momentum is conserved.	Explanation is clear, concise and accurate.
(c)	After firing $m_b v_b + m_r v_r = 0$ $\Rightarrow 0.086 v_b + 9.2 \times (-1.2) = 0$ $\Rightarrow v_b = 128.37209 = 130\ m\ s^{-1}$.	Correct answer but no indication of the correct direction of bullet velocity.	Correct working and answer	
(d)	Impulse = change in momentum $= p_f - p_i = m_b v_b - 0 = 0.086 \times 128.37209$ = 11.04 = 11 N s $F\Delta t = \Delta p \Rightarrow F = \Delta p / \Delta t$ $= 11.04/(37 \times 10^{-3}$ = 298.37838 = 300 N		***Correct answer for impulse with change in mom. as $P_f - P_i$ indicated***	Correct working and answer.
FOUR (a)	$V_H = 25\cos 39.8 = (19.2 ms^{-1})$	Correct working		
(b)	$V_V = 25\sin 39.8 = (16.0 ms^{-1})$	Correct working.		
(c)	$d = v_i t + \frac{1}{2}at^2$ $d = 19.2ms^{-1} \times 3.2s + 0m$ $d = 61.44m = (61m)$		Correct substitution and calculation.	

(d)	Time up = ½ total time = ½ x 3.2s = 1.6s $Height = v_i t + \frac{1}{2}at^2$ $Height = 16ms^{-1} \times 1.6s + \frac{1}{2} \times (-9.8) \times 1.6s^2$ $Height = 13.056m = (13m)$	*Used 3.2s and got 1.024m.*	Correct substitution and calculation.	
(e)	Gravity and air resistance	*both required*		
(f)	The hammer has 2 components of motion: i) uniform velocity in the horizontal direction and … ii) constant acceleration downwards at $9.8ms^{-1}$ (gravity) These combine to give a parabolic path of travel.	*downward acceleration* *OR* *parabolic path*	*both directions described* *OR* *complete answer but lack of clarity.*	both directions described clearly and parabolic path.
(g)	$P = \frac{E}{t} = \frac{2270J}{2.4s} = 946w = (950w)$	Correct working and answer		

Torque AND Vectors Revision Question ANSWERS

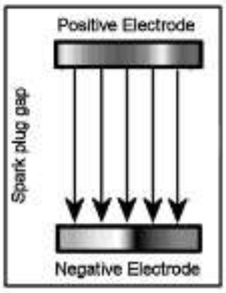
ONE (a)	$W = Fd = F_E d$ = 120 x 0.78 = 93.6 J	Correct formula substitution, working		
(b)	P =W/ t = 93.6/0.95 = 98.52 = 99 watts	Correct answer.		
sf	2 sf	Correct sf		
(c)	$\tau = Fd$ = 120 x 2.1 = 252 (= 250)	Correct answer		
unit	N m	Correct SI unit		
(d)	$\tau_A = \tau_C$ F_g x 0.44 = 252 F_g = 572.73 N *572.73 = mg* m =572.73/10 = 57.3 kg [carried on error possible from (c)]		Correct calculation of weight force.	Correct working and answer.
(e)	The clockwise torque exerted by the effort force about the centre of the wheel is equal to the anti-clockwise torque exerted by the weight of the load and barrow about the same point.	***Clockwise torque is equal to anticlockwise torque***	Explanation is clear and accurate.	

TWO (a)	v = 2.3 – 0.8 = 1.5 ms^{-1} Upstream		
(b)	t = d/v = 25/1.1 = 23 s		
(c)	d = vt = 0.8 x 23 = 18.4 m		
(d)	Correct diagram but not consistent with indicated current direction		
(e) (i)	$V_3 = \sqrt{(1.1^2 + 0.80^2)}$ = 1.4 ms^{-1}		
(e) (ii)	θ = $\tan^{-1}$ (1.1/0.80) = 54°		

three (a)	F = mg = 4.0x9.8 = 39 N		
(b)	Error in rearranging maths or incorrect unit for k.	F = kx k = F/x = 39/1 = 39 Nm^{-1}	
(c)	Moments clockwise = moments anticlockwise. 30x2.1 = Fx0.50 F = 130 N		
(d)	Reduction in length of the rod idea but no linking to torques.	Explanation that is based on the reduction in length of the rod and this is linked to EITHER the reduction in torque from the fish OR the need for less force from Bill.	When the rod bends near the tip the distance from the pivot to the line of action of the force caused by the fish is reduced. This means that the torque (Fxd) produced by the fish on the pivot of the rod is reduced. Thus less force is required to be applied by Bill's left hand on the rod to balance the torque from the fish. Ie for excellence, ideas must be clearly linked as consequences of each other.
(e)		Correct calculation but time of flight not halved	$d = v_i t + 0.5at^2$ (t = 3.4/2 = 1.7 s) $h = 0.5x9.8x1.7^2$ = 14 m
(f)	Friction or drag mentioned.	The tension force AND friction/drag forces mentioned but no linking of the impact of these forces on the horizontal component of motion of the lure	A parabolic flight path assumes that the only force operating on the lure is gravity and so the horizontal component of the velocity is constant. However because the lure is attached to a line, there will be an increasing tension force from the line caused by friction, as well as drag from its path through the air slowing its horizontal velocity component and distorting its parabolic motion.
(g)	Don't accept answers that talk about the greater "leverage" of the longer rod because the greater distance to the lure from Bill's hand means that the force (leverage)on the lure is actually less.	Recognition of the fact that the longer rod accelerates the lure more before release.	Assuming Bill applies the same torque to each rod, a longer rod will mean that the lure is accelerated through a larger arc. This increase in the distance that the Torque (Force) acts on the lure will mean that the lure reaches a higher velocity before it is released. This results in it having a greater casting range.

FOUR (a)	F= mg = 40 x 10 = **400 N**		
(b)		τ = Fd = 680x1.75 + 400x4.25 τ = **2890 Nm**	
(c)	For equilibrium to occur; Total Force must equal zero <u>and</u> Total Torque must equal zero		
(d)	τ = 2890 Nm		
(e)			$\tau = F_B d$ 2890 = F x 3.5 F_B = 826 N Forces up = Forces down F_A + 826 = 680 + 400 F_A = **254 N ≈ 250N (2sigfigs)**

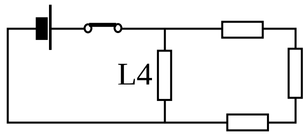
Electric Fields Revision Question ANSWERS

ONE (a)		Diagram has correct shape but incorrect direction or Diagram has correct direction but incorrect shape.	Diagram shows both correct shape and direction of electric field.	
(b)	$E = \frac{V}{d} = \frac{40000}{0.80x10^{-3}}$ $= 5.0 \times 10^{7}$ V m^{-1}	Correct formula, substitution and working.		
(c)Units	NC^{-1}	Correct Unit		
(d)	$F = Eq = 50000000 \times 1.6 \times 10^{-19}$ $= 8.0 \times 10^{-12}$ N (2sf)	Correct answer.		
(e)	$\Delta E_{p\ (lost)} = E_{k\ (gained)}$ $\Delta E_p = E_k = Eqd$ $= 50000000 \times 1.6 \times 10^{-19} \times 0.80 \times 10^{-3}$ $= 6.4 \times 10^{-15}$ J Alternatively $\Delta E_p = E_k = Vq = 40000 \times 1.6 \times 10^{-19}$ $= 6.4 \times 10^{-15}$ J (2sf)		Correct working and answer.	

TWO (a)	NC^{-1}		
(b)	Arrows point to the right.		
(c)	F = Eq = 120000 x $3x10^{-10}$ = $3.6x10^{-5}$ N		
(d)	Calculates voltage drop but does not subtract it from 60000.	V = Ed = 120000 x 0.28 = 33,600 V lower than the plate. Ie Voltage = 60,000 – 33600 = 26400 V	
(e)	W = Fd = $3.6x10^{-5}$ x 0.28 = $1.0x10^{-5}$ J		
(f)		Calculates the current but not able to calculate the charge flow. OR uses correct approach but makes maths error.	I = P/V = 20000/60000 = 0.33 A Q = It = 0.33 x 1 = 0.33 C

DC Circuit Revision Question ANSWERS

One (a)	The amount of electrical potential energy in joules that each coulomb of charge either gains or loses between two points in a circuit.		Explanation shows some understanding of energy per unit charge	Explanation shows clear understanding
(b)	$P = VI \quad 1 = 24I \quad I = 0.0416...A$ $R = \frac{V}{I} = \frac{24}{0.0416...} = 576\ \Omega$	Current correctly calculated.		Correct formulae, substitution and working.
(c)	$I = \frac{Q}{t} \Rightarrow Q = It$ $= 0.04167 \times (45 \times 60)$ $= 112.509$ = 110 C (2sf) *[Carried on error from (b) possible]*		Correct Answer	
(d)	Resistance of each branch $R_{branch} = R_1 + R_2 = 15 + 15 = 30\Omega$ Resistance of circuit $\frac{1}{R_{Total}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{30} + \frac{1}{30} = \frac{2}{30}$ $\Rightarrow R_{Total} = \frac{30}{2} = 15\Omega$ (2sf)	Calculation of resistance of each branch as 30 Ω	Correct formula, substitution and reasoning showing the use of series and parallel resistance concepts.	
(e)	$R = VI \Rightarrow I = \frac{V}{R} = \frac{48}{15} = 3.2\,\text{A}$ (2sf)	Correct Answer		
(f)	Each parallel branch loses 48 V hence each bulb in the series branch has 24 V dropped across it. The current in the circuit is 3.2 A. Therefore each branch has a current of 1.6 A. Circuits in series have the same current flow so each bulb in a branch has a current of 1.6 A $P = VI = 24 \times 1.6 = 38.4$ W = 38 W (2sf) (Alternative: Power for four bulbs $P_T = \frac{V^2}{R} = \frac{48^2}{15} = 153.6\,\text{W}$ Therefore one bulb = 153.6/4 = 38.4 W)	Correct voltage across each lamp stated or Correct current through each lamp stated	Correct current through each lamp stated and Correct voltage across each lamp stated	Correct method and reasoning.
(g)	$P_{4bulbs} = 4 \times 38.4 = 153.6W$ $t_{45\min} = 45 \times 60 = 2700s$ $P = \frac{\Delta E}{t}$ $\Rightarrow \Delta E = Pt = 153.6 \times 2700$ $= 414720$ = 410 000 J (2sf)		Correct method and answer	
sf	2 sf	Correct sf		

Two (a)	Circuit A = series Circuit B = parallel		
(b)	One of the voltages correct	Circuit A = 3V Circuit B = 12V	
(c)		One step of the process apparent.	$P = V^2/R$ $R = V^2/P=144/10 = 14$ Ohm OR 2 step process using P = VI and Ohms law.
(d)	R = 4 x 14 = 56 Ohms		
(e)		One step of solving process clearly understood.	I = V/R = 12/14 = 0.86 A for each branch. So total current = 4 x 0.86 = 3.4 A OR Total R = 14/4 = 3.5 Ohms So I = V/R = 12/3.5 = 3.4 A
(f)		1 step of solving process clearly understood.	P = VI = 12x 0.86 = 10.32 W E = Pt = 10.32 x 3600 = 3700 J
(g)	Some difference in brightness achieved between lamps.	Idea of L4 in its own circuit and others in series but not correct circuit.	
(h)	States one correct comparison. OR gives two characteristics without comparison.	States at least one advantage and one disadvantage in a comparative sense.	Advantages of Circuit A over circuit B. *A has Low current. B has high current which is expensive. Disadvantages * A has One light out all out. B has other lights still working. * A very dim, not up to power. B very bright, all at rated power.
(i) (i)	To allow current to go only one way in a circuit. (Connection protection) OR Rectification of AC to DC.		
(i) (ii)	Draws correct diode symbol.	Has correct diode symbol and diode is the correct way round for circuit to work.	

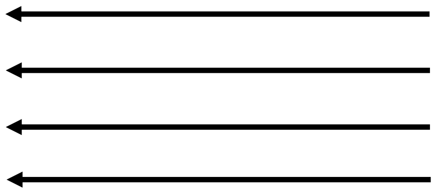
THREE (a)	(2.4kW)(18cents/1kWh)(1 hours) = 43.2cents = 43 cents or $0.43	Correct		

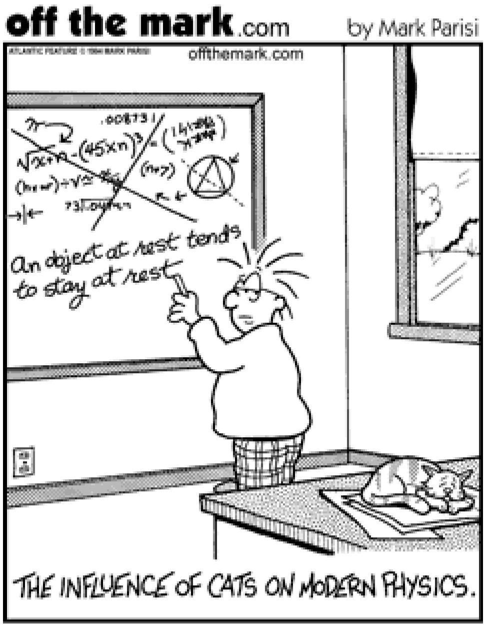
(b)	V = IR 220 = I (60) I = 3.6666666666 P = IV P = (3.66666666)(220) P = 806.67 Cost = (0.81kW)(18cents/kW) Cost = 14.5199 Cost = 15cents		Power of the TV is calculated correctly	All Correct

Forces with Magnets and Induced Voltage Revision Question ANSWERS

ONE (a) (i)	Arrow is into the page.		
(a) (ii)	Chose correct equation but wrong answer.	F = BIl I = F/Bl = 0.02/0.13x0.03 = 5.1 A	
(b)	F = Bqv = 0.13 x $3.9x10^{-5}$ x 2 = 1.0 x 10^{-5} N		
(c)	The magnetic force on the ball is downwards.		
(d)	Graph wrong but idea of speed change mentioned.	Graph shaped like a shallow hill. No or poor explanation.	Graph correct. Reason given that the speed of the ball increases and then decreases with maximum at the lowest point due to gravity.
(e)	Answer correct but not expressed as millivolts.	V = Bvl = 0.13 x 3 x 0.03 = 0.012 V = 12 mV	

Two (a)	$F = BIL$ $\Rightarrow B = \frac{F}{IL} = \frac{0.23}{0.50 \times 19.7 \times 10^{3}}$ $= 2.335 \times 10^{-5}$ $= 2.3 \times 10^{-5}$ T (2sf)	Correct formula, substitution and working.		
(b)	Assumptions: - uniform magnetic field strength - length of the conductor is perpendicular to magnetic field direction (i.e. sin(θ) = 1) - speed of the shuttle-conductor system is constant		Two correct assumptions	Three correct assumptions
(c)	The system produces a voltage difference across the length of the conductor. There is no physical way of completing the circuit to allow a continued current. The magnetic force on the electrons would force electrons to one end of the conductor until the voltage caused by the charge separation is equal and opposite to the force that produced it.	Idea of a non complete circuit.	Achieved plus idea of charge separation.	Merit plus production of opposing voltage by charge separation stopping the current.

(d)	$V = BvL$ $\Rightarrow v = \frac{V}{BL} = \frac{3500}{2.335\times10^{-5}\times19.7\times10^{3}}$ $= 7608.8$ = 7600 m s^{-1} (2sf)	***L not converted into metres resulting in an answer of 7.6 x 10^{6} ms^{-1}***	Correct answer	
(e)	Increase the length of the conductor. Increase the speed of the shuttle-conductor system.	Increased length and speed clearly stated		
THREE (a)	$F = Bqv$ $\Rightarrow B = \frac{F}{qv} = \frac{2.5\times10^{-15}}{1.6\times10^{-19}\times630\times10^{3}}$ = 0.0248015873 = 0.025 T (2sf)	Correct answer		
(b)		Either shape or direction is correct	Both shape and direction are correct	
(c)	Given a correct Hand Rule and relates to the given situation For example, the R.H. Slap rule: • palm pointing upwards because the beam is moving up • thumb pointing opposite to electron flow, because it is the direction of the conventional current flow. • The fingers are pointing to the direction of the magnetic field, which is from left to right.		Correct rule relating to the situation	



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