Name: Set:

5th Form Physics
Summer 2016

This exam covers the topics of:

- Kinematics
- Dynamics
- Energy
- Electricity
- Radioactivity

Marks will be awarded for **correct and clear working**. Correct answers with no clear method will only receive some of the marks.

Take g = 10m/s^2

There are 5 sections and 60 marks to be completed in 60mins.
You should spend approximately 1min/mark.

Section 1 (multiple choice): **(10)**

CDBE BDDA AB

Q1. The energy required to lift a 5kg bag of potatoes onto a shelf 1.5m off the floor in a supermarket, is approximately:

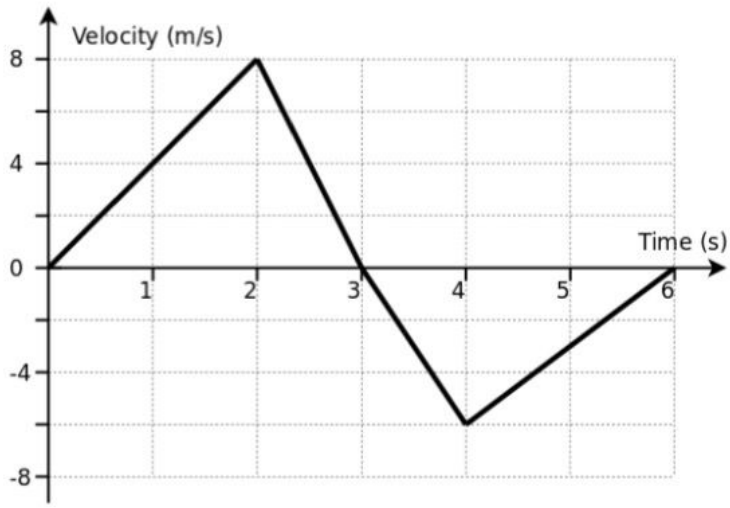
A. 7.5J
B. 50J
C. 75J
D. 112J
E. More information needed

Q2. A teacher has to pick up a vital policy document at exactly 11am. The journey involves 32km of roads where the average speed is 80kph. The journey must start at:

A. 10:24
B. 10:28
C. 10:32
D. 10:36
E. 10:40

Q3. A tennis player moves in a straight line with a velocity as shown in the graph below. Their final displacement from their starting position is:

A. 0m
B. 3m
C. 4.5m
D. 9m
E. 12m



Q4. An object of weight 20N drops from rest to the ground 10m below. The force it applies when It strikes the ground is about:

A. 10N
B. 20N
C. 40N
D. 200N
E. Can't be determined from this information

Q5. A radioactive source points at a Geiger-counter 1cm away. Moving the detector to 5cm from the source reduces the radiation detected a little. However, when a 5mm aluminium sheet is then placed in front of the detector the count level reduces dramatically:

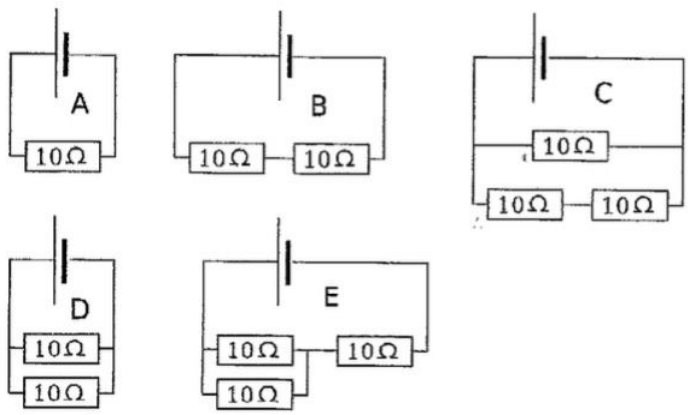
A. Alpha
B. Beta
C. Gamma
D. Beta & Gamma
E. Alpha & Gamma

Q6. An aircraft of mass 4000kg produces a thrust of 10kN. The aircraft needs to travel at 35m/s to take off. From a standing start, the time to become airborne is approximately:

A. 2.5s
B. 3.5s
C. 9s
D. 14s
E. 88s

Q7. The 5 circuits shown all contain a 2V cell and various combinations of 10Ω resistors. In which circuit is the greatest power dissipated?

A B C **D** E



Q8. The electric plug on a metal toaster is incorrectly wired. Only one of the three connections is made to the correct terminal - the other two are the wrong way round. The toaster delivers a potentially lethal shock to anyone who touches the metal casing. Which wire is *correctly* connected?

A. Neutral
B. Live
C. Earth
D. Red Wire
E. Brown Wire

Q9. Two warthogs have equal kinetic energy when running at top speed. One runs 5% faster than the other. This means the mass of the faster one is:

A. 10% less than the slower one

B. 5% less than the slower one

C. 2.5% less than the slower one

D. The same as the slower one

E. 5% more than the slower one

Q10. A student performs an experiment to measure the half-life of a radioactive isotope. First they use a Geiger-counter and measure the background radiation to be 120counts/min. Next they measure the activity with the radioactive isotope in place and record a reading of 1080counts/min. Finally they repeat the experiment 12hrs later with the radioactive isotope still in place and record a count rate of 240counts/min. The half life of the sample is approximately:

A. 6hrs

B. 4hrs

C. 3hrs

D. 2hrs

E. Cannot be determined from the above information

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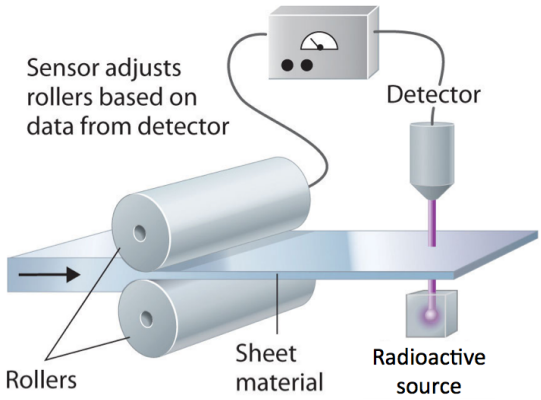
Exam continues overleaf

Section 2 (radioactivity) **(15)**

1. A radioactive source is used in a factory producing thick plastic sheets. Explain how the detected count would change if the sheet were too thick and what subsequent action should be taken:



Change in count rate: *Decreases / reduces* (1)

Subsequent action: *Move rollers closer together / press harder / reduce the gap (wtte)* (1)

***[Don't allow**: change the source / move the detector closer]*

2. The team commissioning the factory are presented with the following radioactive isotopes. Which one should they choose and why?

Isotope	**Type of radiation**	**Half-life**
Uranium-238	Alpha	4,500,000,000 years
Proactinium-234	Beta & Gamma	60 seconds
Polonium-218	Beta	2 days
Lead-214	Alpha & Beta	14 years
Bismuth-210	Gamma	1 year

Isotope: *Lead-214* (1)

Reason: (2)

1 mark for a sensible comment about penetrating power:

- *E.g. Alpha not penetrating enough by itself (i.e. not U-238) and gamma too penetrating to change (i.e. not Pa-234 or Bi-210)*

1 mark for a sensible comment about half-life:

- *E.g. Po-218 half-life is too short therefore needs calibration too often*

If answer focusses only on Pb-214, must be specific - i.e. "penetrating enough but not too penetrating" would not score marks.
Cannot score both reasoning marks without discussing both penetration and half-life

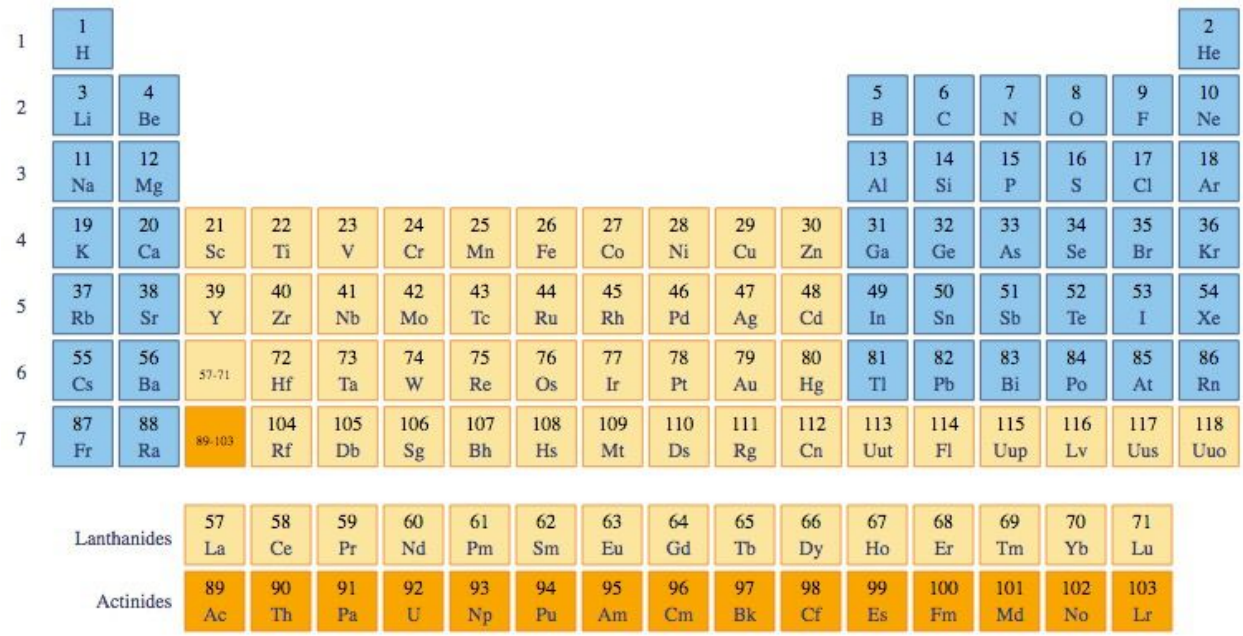
3. U-233 undergoes beta decay and the product then subsequently undergoes alpha decay. Using the periodic table below, complete the following equations adding mass numbers, atomic numbers and element symbols for the products

$$^{233}_{92}U \rightarrow \ ^{233}_{93}Np + \ ^{0}_{-1}\beta \rightarrow \ ^{229}_{91}Pa + \ ^{4}_{2}\alpha$$

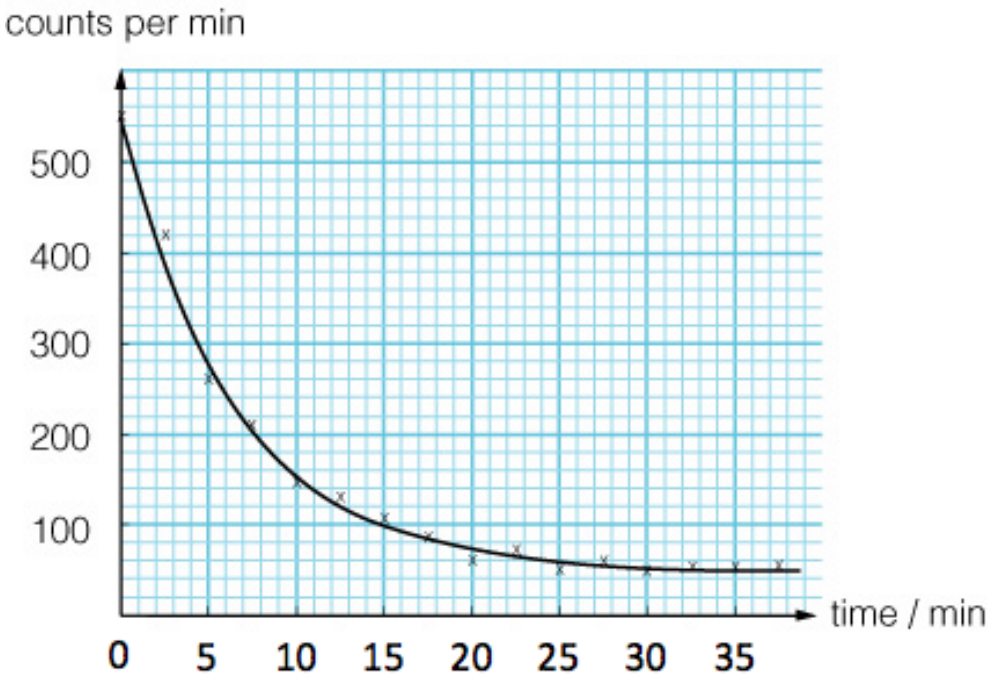
(5)

- *Both 233 and 93*
- *Both Np and Pa (ecf to match their atomic numbers e.g. 92 would give U)*
- *229*
- *91*
- *Both 4 and 2*

Nb/ markscheme originally had a mistake. See above for correct version.



The below graph has been plotted after recording the count rate of a Geiger-counter next to a radioactive sample in a lab.



4. Use the graph (show your working on the graph) to determine the half-life of the sample: (2)

- *Answer between 4 & 6 inclusive*
- *Some evidence of working on the graph*

[If student makes a good attempt at correcting for background here and thus gets confused for Q5, award full marks for both sections for making it too hard!]

5. The half-life is actually likely to be quite different from that which you just calculated. State whether the half-life will be longer or shorter than your calculation, and explain your reasoning: (2)

- *Have not subtracted (or taken into account) background radiation*
- *Half-life will be shorter*

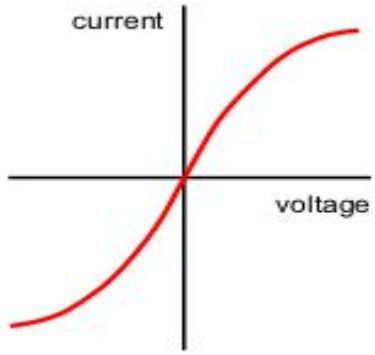
Don't allow "randomness"

6. The sample was placed on a set of scales during the experiment. If the mass of the initial sample was 1kg, what would be the approximate readings on the scales the following morning? (1)

- 1kg

Section 3 (electricity): **(7)**

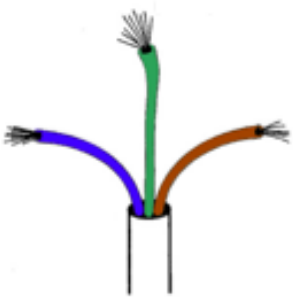
This graph shows the I-V characteristics of a filament-bulb.



1. With reference to the graph, explain what happens to the resistance of the bulb as V increases, and why:

R increases *(1)*
Any two of: *(2)*

- *I increases*
- *Therefore more collisions*
- *Therefore temperature increases (wtte)*



DO NOT TRY THIS AT HOME

2. This diagram is the end of a frayed cable, the other end of which is plugged into a UK socket that is turned on. If I touched the live wire (only), explain what would happen to each of the below safety devices:

The plug's 5A fuse = (2)

- *Nothing*
- *Body's R is high therefore the current would not be big enough to melt the fuse (wtte)*

The room's RCD = (2)

- Trip, switch off, shutdown (wtte)
- $I_{live} > I_{neutral}$ (accept I_{live} and $I_{neutral}$ are"different")

Section 4 (energy) **(12)**

This question considers planes approaching Heathrow from St Paul's to the point at which they land. The below information is useful for this section:

	St Paul's	Heathrow
Altitude	1.5km	0m
Horizontal distance from St Paul's	0m	16km
Plane speed	150m/s	100m/s

1. An approaching Boeing 747 has a mass of 400,000kg therefore calculate the magnitude of the Gravitational Potential Energy lost between the two locations: (3)

- *GPE = mgh*
- *400000 x 10 x 1500 (i.e. conversion)*
- *6,000,000, 000J (6GJ)*

6MJ scores 2 marks

2. Calculate the magnitude of the loss of Kinetic Energy between the two locations: (4)

- *KE = ½mv²*
- *=½ x 400,000 (150²-100²)*
- *2.5GJ*
- *Units of J seen in either Q1 or Q2*

0.5GJ scores only 1st and 4th mark (i.e. not doing difference of 2 squares)
4.5GJ scores only 1st and 4th mark (i.e. not subtracting original KE)

3.

- A student from Westminster suggests calculating the difference between the above answers to find the Work Done by air resistance, and subsequently finding the average frictional force.
- A student from KCS insists you should add the two values to find the Work Done by air resistance, to subsequently find the average frictional force.

Circle below which student you agree with, then use his/her method to find the average frictional force: (4)

I agree with the Westminster / **KCS** student:

- *KCS*

- *Work done = Force x Distance*
- *Some evidence of hypotenuse and/or acknowledgement that 10km is an approximation (d = $\sqrt{(16000^2+1500^2)}$ = 16,070). Use of 10,000m without explanation does not get a mark*

If KCS:

- *(Answer to Question 1 + Answer to Question 2) / d = 520kN*

Ecf if they chose Westminster but then achieved the below:

- *(Answer to Question 1 - Answer to Question 2) / d = 218kN*

[ECF from Answer to Question 1 and Answer to Question 2 - sorry, probably a pain to work out…!]

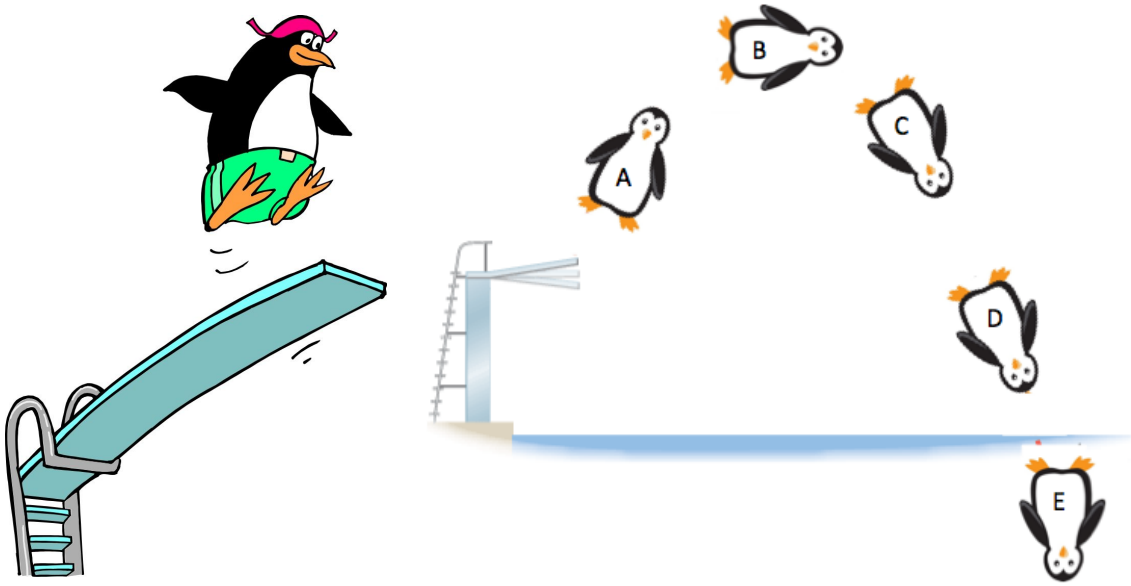
4. What have both students failed to take into account? You must be specific in your answer to avoid joining them at 16+ entry: (1)

Specific example of an energy transfer that has been neglected: e.g. KE of exhaust air, fuel burnt in the engines, sound from the engines, etc.

[If this is where they discuss hypotenuse, award the mark.]

Section 5 (Kinematics & Dynamics): **(16)**

Donald Trump has recently suggested he would eliminate the US budget deficit in 10 years. One of his cost-cutting plans is to replace the *US Navy Seals* with a cheaper alternative; the *US Navy Penguins*. To prepare for his possible election, they are practising landings in water by jumping off a diving board:



Throughout this section, assume air resistance is negligible but water resistance is substantial.

1. Fill in the below table. Where known, specific values should be included, otherwise examplar values should simply be included. **No calculations are required**:

Location	Vertical Velocity	Vertical Acceleration	Horizontal Velocity	Horizontal Acceleration
A	4m/s ↑	↓ 10m/s^2	3m/s →	0m/s^2
B	0m/s		3m/s →	
C	X ↓			
D	Y ↓			
E	5m/s ↓	Anything ↑	1m/s →	Anything ←

(6)

Mark per red box in my version above:

- *Vertical velocity at B is 0m/s*
- *X and Y both downwards, with sensible numbers (i.e. Y>X, Y>5)*

- *Vertical acceleration in all air cases is 10m/s^2*
- *Vertical acceleration in water is upwards*
- *Horizontal velocity in air is always 3m/s*
- *Horizontal acceleration in air is therefore always 0m/s^2*
- *Horizontal acceleration in water is therefore left*

2. Complete force diagrams for the best diver (Eric) at the various stages of his dive:

- *Weight is the same (by eye) in all 3 diagrams*
- *No other forces acting on A or C (it did say air resistance is negligible)*
- *E has buoyancy upwards*
- *E has drag upwards and left (can be as two components or as a diagonal)*

[Nb/ E drag + buoyancy should be > weight. Your call…!]

(4)

Gave zero if they just drew arrows.

3. One of the primary skills for US Navy Seals is being able to drop quickly into enemy territory. Donald Trump has therefore asked you to compare the <u>terminal</u> <u>velocity</u> of "*Eric the Penguin*" with his predecessor "*Donald (Jr) the Seal*".

Use the data and formula overleaf to calculate the terminal velocity of *Eric*:

	Donald (Jr) the Seal	***Eric the Penguin***
Mass	250kg	50kg
Surface Area	6000cm^2	1500cm^2
Terminal Velocity	35m/s	???

Drag Force = kAv^2

- k is a constant
- A is the surface area
- v is the speed of the object. (4)

Likely a lot of students will try to use ratios (an acceptable method) but they will need to be clear with working if so. Whether ratios and/or working out a value of k and re-substituting, would expect to see:

- *Evidence of mass factor of 5*
- *Evidence of surface area factor of 4*
- *Evidence of square-root to find v*
- *Answer = 31m/s*

4. Hence explain whether Donald Trump should replace the *US Navy Seals* with the *US Navy Penguins*...

No marks as indicated in the question, but include any funny answers as a comment here!

(0)

END OF PAPER

SPACE FOR ADDITIONAL WORKING _____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