Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

3430UF0-1

Z22-3430UF0-1

WEDNESDAY, 8 JUNE 2022 – AFTERNOON

SCIENCE (Double Award)

Unit 6 – PHYSICS 2
HIGHER TIER

1 hour 15 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**7**	
2.	**8**	
3.	**7**	
4.	**14**	
5.	**13**	
6.	**11**	
Total	**60**	

ADDITIONAL MATERIALS

In addition to this examination paper, you may require a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.
You may use a pencil for graphs and diagrams only.
Write your name, centre number and candidate number in the spaces at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.
The assessment of the quality of extended response (QER) will take place in question **4(a)**.

PJ*(X21-3430UF0-1)

Equations

speed = $\frac{\text{distance}}{\text{time}}$	
acceleration [or deceleration] = $\frac{\text{change in velocity}}{\text{time}}$	$a = \frac{\Delta v}{t}$
acceleration = gradient of a velocity-time graph	
distance travelled = area under a velocity-time graph	
resultant force = mass × acceleration	$F = ma$
weight = mass × gravitational field strength	$W = mg$
work = force × distance	$W = Fd$
kinetic energy = $\frac{\text{mass} \times \text{velocity}^2}{2}$	$\text{KE} = \frac{1}{2} mv^2$
change in potential energy = mass × gravitational field strength × change in height	$\text{PE} = mgh$
force = spring constant × extension	$F = kx$
work done in stretching = area under a force-extension graph	$W = \frac{1}{2} Fx$

SI multipliers

Prefix	Multiplier
p	1×10^{-12}
n	1×10^{-9}
μ	1×10^{-6}
m	1×10^{-3}

Prefix	Multiplier
k	1×10^{3}
M	1×10^{6}
G	1×10^{9}
T	1×10^{12}

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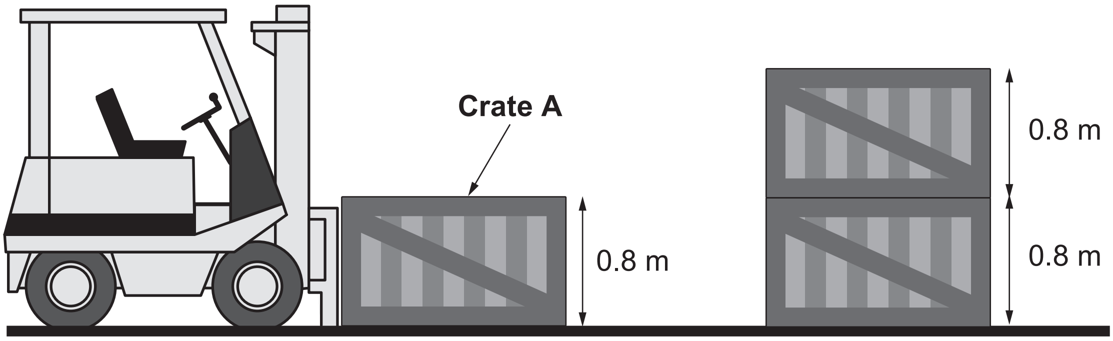
Answer **all** questions.

1. On a farm a fork-lift truck is used to stack wooden crates of Welsh apples.



(a) (i) Each crate of apples has a weight of 450 N and is 0.8 m high.
Use an equation from page 2 to calculate the work done in putting **crate A** on top of the **2 other** crates. [3]

Work done = ... J

(ii) State the gain in potential energy (PE) of the crate when lifted on to the stack. [1]

Gain in PE = ... J

(iii) Give a reason why the fork-lift truck uses more energy lifting crate A than the work done calculated in part (i). [1]

....

....

(b) Each crate of apples has a weight of 450 N.
The mass of the empty crate is 12 kg.
Calculate the mass of apples contained in the crate.
(On Earth, an object of weight 10 N has a mass of 1 kg.) [2]

Mass of apples = ... kg

7

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2. Jupiter has 79 moons in orbit around it. The table shows data for 4 of its moons.

Name of moon	Mean diameter (km)	Mean temperature (°C)	Orbit radius (km)	Orbit time (days)
Io	3 660	−163	421 700	1.8
Europa	3 120	−171	671 000	3.6
Ganymede	5 260	−163	1 070 400	7.2
Callisto	4 820	−139	1 882 700	16.7

Use information from the table above to answer the following questions.

(a) (i) State which moon has the highest mean temperature. .... [1]

(ii) For the solar system, as the orbit radius increases around the Sun, the mean temperature of the planets generally decreases.
Explain why the orbit radius of the moons around Jupiter does not affect their temperatures in the same way. [2]

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(iii) Peter states that as Callisto has the longest orbit time it must be the largest moon.
Determine whether Peter's claim is correct. [1]

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(iv) Peter correctly notices that Ganymede has an orbit time that is exactly double Europa's.
Peter suggests that as the orbit time **doubles**, the orbit radius also **doubles**.
Use **only** the data for Ganymede and Europa to determine whether Peter's claim is true. [1]
Space for calculations.

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(b) (i) Two of the statements listed below are correct. One correct statement has already been ticked.
Tick (✓) **one more box** to show the other correct statement. [1]

An Astronomical Unit (AU) is the mean distance that separates the Earth and the Sun.	✓
A light year is a measurement of time.	
A light minute is the distance travelled by light in 60 seconds.	
A light year is smaller than a light second.	

(ii) Both Earth and Jupiter travel in elliptical paths around the Sun.
As they orbit the Sun the closest distance between Jupiter and Earth is 588 000 000 km. This is equivalent to 3.92 AU.

Calculate the distance, in km, that separates the **Earth and the Sun**. [2]
(1 AU = Earth to Sun distance)

Distance = ... km

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3. Carbon-12 ($^{12}_{6}C$) and carbon-14 ($^{14}_{6}C$) are isotopes.

(a) Explain, in terms of the **numbers of particles**, why carbon-14 has an unstable nucleus and carbon-12 has a stable nucleus. [3]

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(b) An unstable nucleus becomes more stable following the emission of radiation. **Complete the table below.** [4]

Type of radiation	Symbol	Description
gamma	....	Electromagnetic (em) wave
alpha	$^{4}_{2}\alpha$	....
beta	....	....

7

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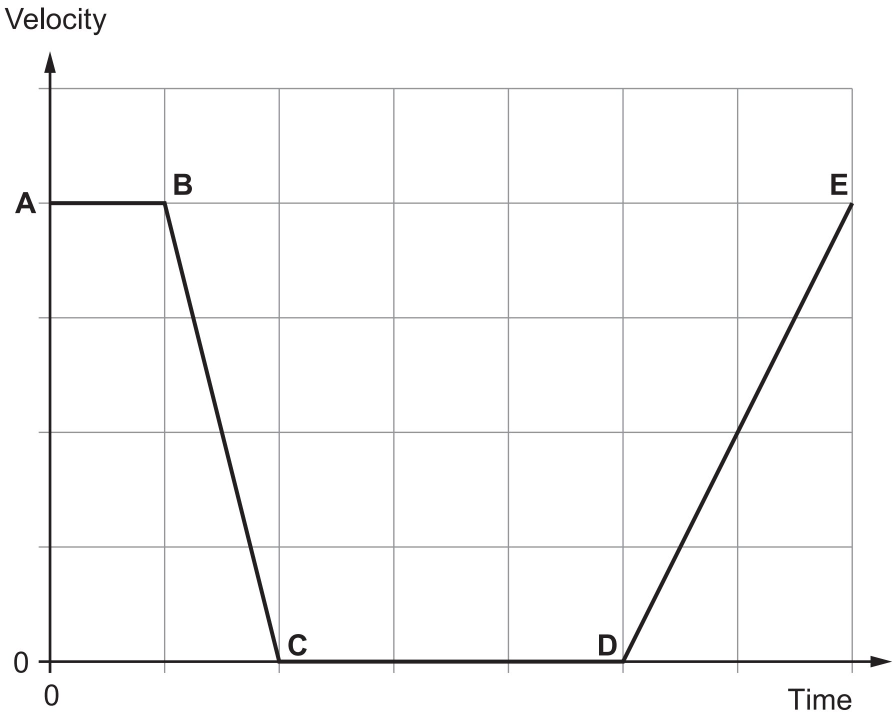
4. (a) Since 2017, new bi-modal electric/diesel trains have been introduced to run between Swansea and London.
A velocity-time graph for one of these trains is shown below.



Use information from page 2 to **compare** the distances travelled **and** accelerations for the parts of the journey labelled **AB**, **BC**, **CD** and **DE**. [6 QER]

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(b) The diagram shows a 5-carriage bi-modal electric/diesel train.

The table below shows information about two types of bi-modal electric/diesel trains.

Train	Mass ($\times 10^5$ kg)	Maximum speed (m/s)	Standard acceleration (m/s^2)	Standard deceleration (m/s^2)	Emergency deceleration (m/s^2)
5 carriage	2.3	55.8	0.7	1.0	1.2
9 carriage	4.4	55.8	0.7	1.0	1.2

For the journey from Swansea to London **two** of the 5-carriage trains are joined, making a 10-carriage train.
The 10-carriage train has the same speed and acceleration as a 5-carriage train.

(i) State Newton's second law of motion as an equation. [1]

....

(ii) Use information from the table to answer the following questions.

I. Use an equation from page 2 to calculate the resultant force needed to accelerate the 10-carriage train. [2]

Resultant force = ... N

II. Use the equation:

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time}}$$

to calculate the time taken to accelerate the 10-carriage train from rest to its maximum speed. [2]

Time = ... s

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(iii) A student states that the 9-carriage train is approximately **double** the mass of the 5-carriage train and if they are both travelling at the same speed it will take approximately **double** the time to stop in an emergency.
Explain whether the **2 claims** made by the student are correct. [3]

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14

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09

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5. An experiment was carried out by students to investigate the mean speed of a stack of 6 cake cases falling from different heights.
The weight of 6 identical cake cases was measured 5 times.
Their results are shown below in **Table 1** and there were no anomalies.

Table 1

Measurement	1	2	3	4	5
Weight of 6 cake cases (N)	0.036	0.032	0.033	0.034	0.030

(a) (i) Calculate the mean weight of the 6 cake cases. [1]

Mean weight = ... N

(ii) Use the equation:

$$\text{uncertainty} = \frac{\text{maximum value} - \text{minimum value}}{2}$$

to calculate the uncertainty in the mean weight of the 6 cake cases. [1]

Uncertainty in the mean = ... N

(iii) The teacher states if the percentage uncertainty in the mean is **less than 10%** the data is repeatable.

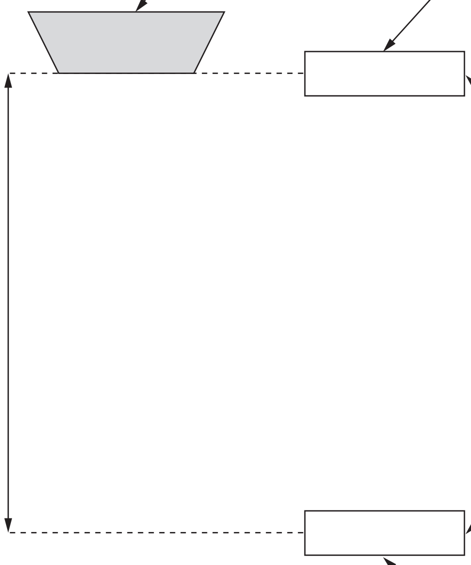
Use the equation:

$$\text{percentage uncertainty} = \frac{\text{uncertainty in the mean}}{\text{mean weight}} \times 100\%$$

to determine if the data collected is repeatable. [2]

....

(b) Light gates were used to time the falling cake cases.
The vertical distance between the two light gates was adjusted so that different drop heights could be investigated.
The apparatus is shown below.



Their results are shown in **Table 2** below.

Table 2

Drop height (m)	Time taken for the stack of 6 cake cases to fall (s)			Mean speed (m/s)
	Trial 1	Trial 2	Mean	
0.00				0.00
0.20	0.365	0.366	0.366	0.55
0.60	0.698	0.697	0.698	0.86
0.90	0.916	0.920	0.918	0.98
1.20	1.133	1.131	1.132	1.06
1.60	1.455	1.454	1.455	1.10
2.00	1.816	1.820	1.818	1.10
2.50	2.270	2.274	2.272	1.10
3.00	2.729	2.725	2.727	1.10

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(i) Give a reason why light gates, rather than a stopwatch, are used to measure the time taken for the stack of cake cases to fall. [1]

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....

(ii) A student correctly notices that the mean speed of the cake cases at a drop height of 1.60 m is **double** the mean speed at a drop height of 0.20 m.
The student states that the cake cases have **4 times** more kinetic energy after falling 1.60 m compared to 0.20 m.

Use an equation from page 2 to investigate whether the claim is correct.
The total mass of the 6 cake cases is 3.3×10^{-3} kg. [3]
Space for calculations.

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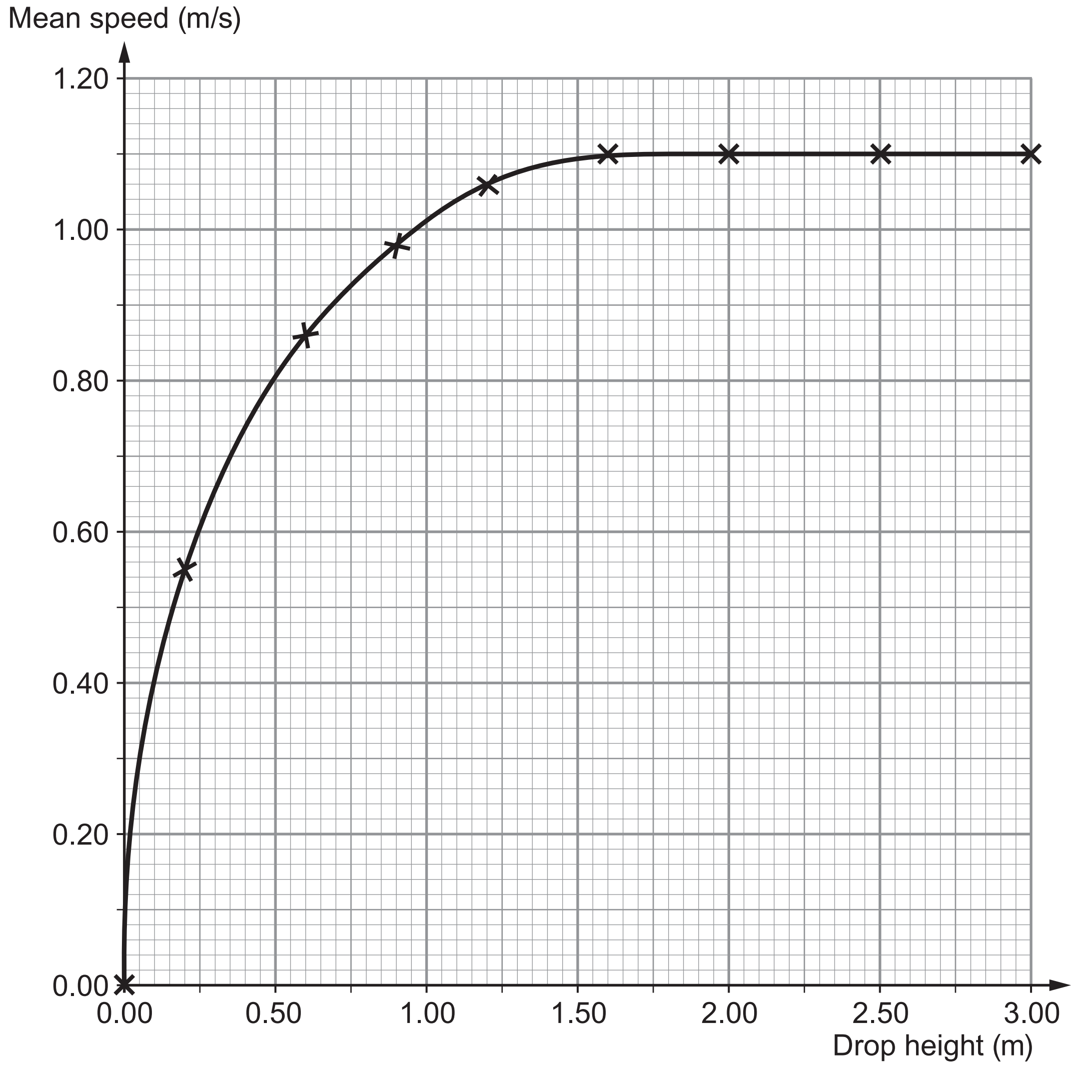
Examiner only

(c) A graph of mean speed against drop height for the 6 cake cases is shown below.



(i) Describe how the mean speed varies with drop height between **0.00 m and 1.50 m**. [2]

....

....

(ii) Use the graph to state the value of terminal speed for the cake cases. [1]

Terminal speed = ... m/s

(iii) I. Name the **two** forces acting on the falling cake cases. [1]

....

II. Compare the size of these two forces when the cake cases fall at terminal speed. [1]

....

13

Turn over.

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6. Following the Chernobyl nuclear reactor accident in 1986, RIMNET (Radiation Incident Monitoring Network) was installed across the UK to monitor the consequences for the UK of nuclear incidents abroad.
GM tubes are used to measure background levels of radiation.
The permanent monitoring stations in Wales are located in the places shown on the map below.

(a) Suggest why there is **more than one** monitoring station located in Wales. [1]

....

(b) The background count at one of the monitoring stations is 24 counts per minute. Explain how, using a stopwatch and GM tube connected to a counter, an accurate value for the background count is determined. [2]

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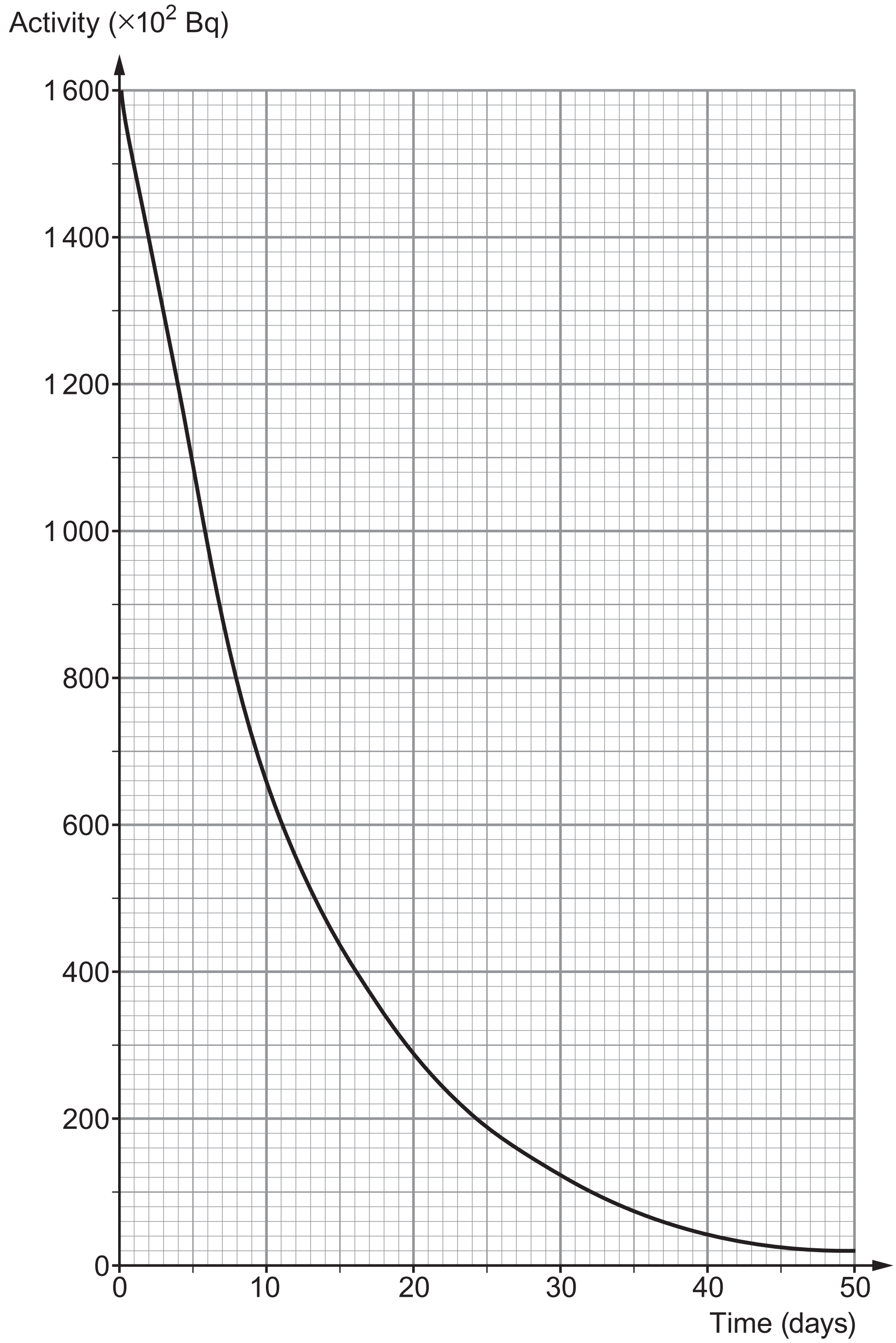
Examiner only

(c) Two radioisotopes released from the Chernobyl accident were iodine-131 (I-131) and caesium-137 (Cs-137).
The decay curve for a sample of I-131 is shown on the graph below.



(i) State the meaning of half-life. [2]

....

....

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(ii) Use information from the graph to determine the half-life of I-131. [1]

Half life = ... days

(d) A sample of Cs-137, with an activity of 1.5 kBq, was obtained from near Chernobyl. Calculate the time taken for this sample to reach a safe limit of $\frac{1}{512}$ of its original activity. The half-life of Cs-137 is 30.2 years. [3]
Space for calculations.

Time taken = ... years

(e) Explain why in 2021, 35 years after the nuclear accident, scientists were concerned about the Cs-137 contamination in the Chernobyl area but not I-131. [2]

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END OF PAPER

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