Write your name here

Surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number | Candidate Number

Physics
Advanced
Unit 4: Physics on the Move

Thursday 15 June 2017 – Morning
Time: 1 hour 35 minutes

Paper Reference
WPH04/01

You must have:
Ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over

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Pearson

SECTION A

Answer ALL questions.

For questions 1–10, in Section A, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which of the following particles is a lepton?

☐ **A** muon

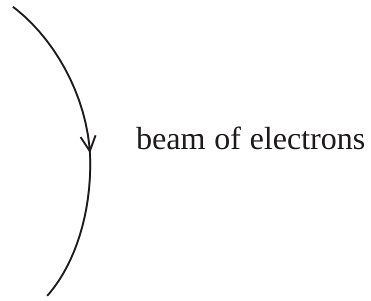
☐ **B** neutron

☐ **C** pion

☐ **D** proton

(Total for Question 1 = 1 mark)

2 A beam of electrons is made to travel in a circular path by applying a magnetic field across the path of the beam.



Which of the following is the direction of the magnetic field required to maintain this circular path for the electron beam?

☐ **A** out of the page

☐ **B** into the page

☐ **C** left to right

☐ **D** right to left

(Total for Question 2 = 1 mark)

3 A toy car rolls down a slope. A graph is plotted of momentum against time.
Which of the following is represented by the gradient of the graph?

☒ **A** acceleration

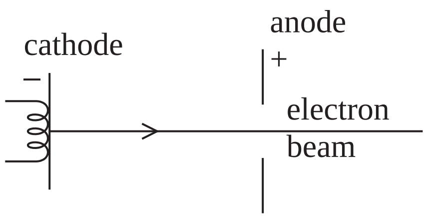
☒ **B** kinetic energy

☒ **C** resultant force

☒ **D** speed

(Total for Question 3 = 1 mark)

4 A beam of electrons is produced to investigate the wave properties of particles.
The beam is obtained by accelerating the electrons across a potential difference.



Which of the following would decrease the wavelength associated with the electrons?

☒ **A** applying a smaller potential difference between the cathode and the anode

☒ **B** decreasing the momentum of the electrons

☒ **C** increasing the distance between the cathode and the anode

☒ **D** increasing the velocity of the electrons

(Total for Question 4 = 1 mark)

5 Accelerators are used to collide high energy particles so that their interactions can be studied.

Which of the following quantities is **not** always conserved in an interaction between particles?

☒ **A** charge

☒ **B** energy

☒ **C** momentum

☒ **D** rest mass

(Total for Question 5 = 1 mark)

6 A potential difference of 0.2 V is applied across parallel plates with a separation of 4 cm.

What is the electric field strength halfway between the plates?

- **A** $0.05\ \text{V m}^{-1}$
- **B** $0.1\ \text{V m}^{-1}$
- **C** $5\ \text{V m}^{-1}$
- **D** $10\ \text{V m}^{-1}$

(Total for Question 6 = 1 mark)

7 Which row of the table shows a possible arrangement of quarks in a baryon and a meson?

	baryon	**meson**
A	$dd\bar{s}$	cd
B	ddu	du
C	$\bar{d}\bar{u}\bar{u}$	$c\bar{s}$
D	$\bar{u}\bar{s}s$	$d\bar{d}$

(Total for Question 7 = 1 mark)

8 Which of the following is a vector quantity?

- **A** kinetic energy
- **B** magnetic flux density
- **C** permittivity of free space
- **D** work done

(Total for Question 8 = 1 mark)

9 The diagram shows the paths of two charged particles, X and Y, moving through the same uniform magnetic field.

Which row of the table describes the properties of Y compared to those of X?

	Charge of Y	Mass of Y	Speed of Y
☒ **A**	the same	greater	the same
☒ **B**	greater	smaller	the same
☒ **C**	smaller	the same	greater
☒ **D**	the same	greater	greater

(Total for Question 9 = 1 mark)

10 A non-relativistic particle of mass m has momentum p and kinetic energy E_k.

Another non-relativistic particle of mass $2m$ has momentum $\frac{p}{2}$.

What is the kinetic energy of the second particle?

☒ **A** $\frac{E_k}{8}$

☒ **B** $\frac{E_k}{2}$

☒ **C** E_k

☒ **D** $2\,E_k$

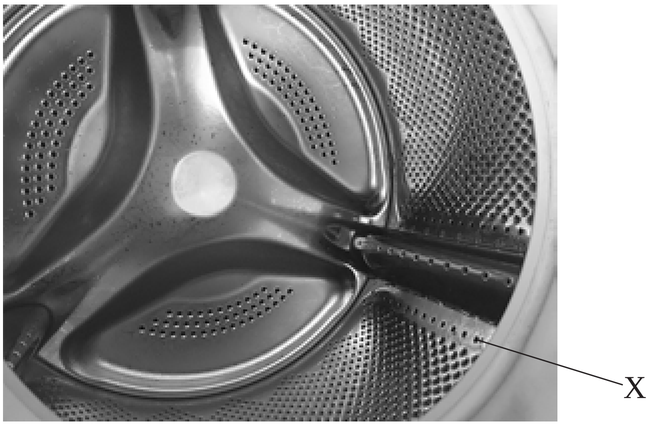
(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 The photograph shows the drum inside a washing machine.



The drum is a hollow metal cylinder with a series of holes through its surface. During the spin cycle the drum rotates at 1400 revolutions per minute to separate the water from the wet clothes.

(a) (i) Show that the speed of the point X on the rotating drum is about 35 m s^{-1}.

diameter of drum = 0.480 m

(2)

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(ii) A shirt button remains at a single point on the drum as the drum spins.

Calculate the centripetal force acting on the shirt button.

mass of shirt button = 1.4 g

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Centripetal force = ...

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(b) Explain how the drum spinning separates water from the wet clothes.

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(Total for Question 11 = 6 marks)

12 It is thought that an asteroid on a collision course with Earth could be deflected by making a fast moving spacecraft collide with it when it is still very far away.

To test this idea, there are plans to send a spacecraft, DART, to collide with a small asteroid. After the collision, DART and the asteroid will stick together.

DART will have a relative speed of 6250 m s^{-1} when it collides with the asteroid. This is expected to cause a change in the asteroid's velocity of 0.40 mm s^{-1}.

(a) Show that the mass of the asteroid is about 5×10^9 kg.

mass of DART = 300 kg

(3)

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(b) Suppose that DART will collide at 90° to the direction of the asteroid's velocity. The asteroid is orbiting at a speed of 0.16 m s^{-1} about a larger partner.

Calculate the angle through which the velocity of the asteroid is deflected.

(2)

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Angle = ...

(Total for Question 12 = 5 marks)

13 (a) Two point charges of 3.1×10^{-9} C and -2.4×10^{-8} C are placed a distance of 0.043 m apart in a vacuum.
Calculate the magnitude of the force between the charges.

(2)

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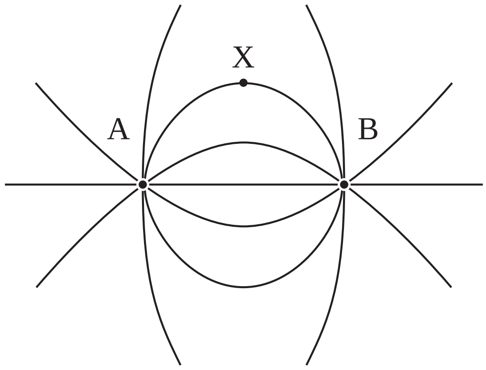
Force = ...

(b) The diagram represents the electric field around two point charges of equal magnitude. A is a positive charge and B is a negative charge.



(i) State the meaning of electric field strength.

(1)

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(ii) By considering the electric field at X due to A and due to B separately, explain the direction of the electric field at X.

(4)

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(Total for Question 13 = 7 marks)

14 The photograph shows a digital coulombmeter which measures electric charge.

The charge the coulombmeter is measuring is stored on a capacitor inside the meter. A voltmeter inside the coulombmeter measures the potential difference across the capacitor. This value is converted so that the display shows the charge in nanocoulomb.

(a) State why the voltmeter must have a very high resistance.

(1)

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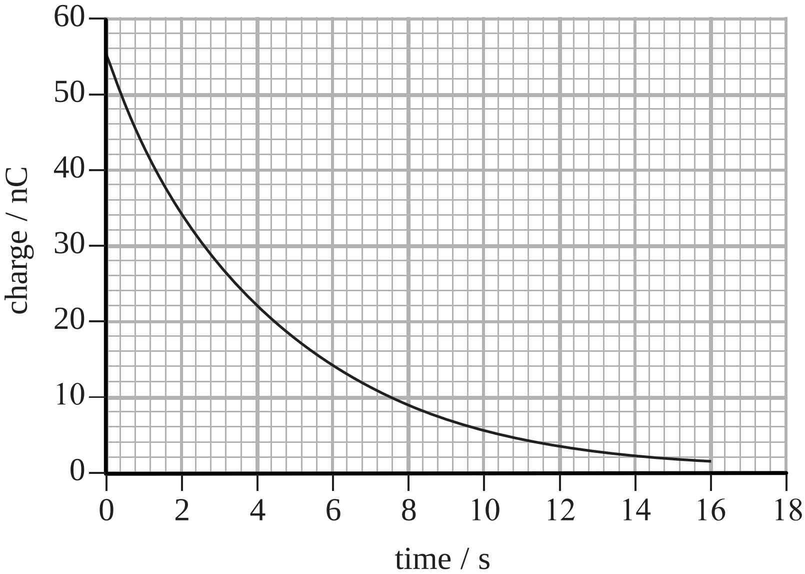
(b) A coulombmeter is charged. A resistor with resistance 4.6 MΩ is placed across the terminals and the capacitor discharges through the resistor. The charge shown on the display is recorded and a graph of charge against time is produced.



(i) Use the graph to determine the capacitance of the capacitor in the coulombmeter.

(3)

Capacitance = ...

(ii) Calculate the energy initially stored by the capacitor.

(2)

Energy = ...

(c) The notes with the coulombmeter state:

The coulombmeter has a much higher capacitance than the charged objects it is being used with, so effectively all of the charge is transferred to the meter.

Explain why the charge will be transferred to the capacitor with a much higher capacitance.

(2)

(d) The data for the graph was obtained by using a video camera to record the coulombmeter display and replaying this frame by frame.
State an advantage of using this method.

(1)

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(Total for Question 14 = 9 marks)

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15 The photograph shows a torch with batteries that are recharged by shaking the torch.

Inside the torch is a coil of wire and a magnet that can move freely through the coil in alternate directions when the torch is shaken. The coil is connected to a rechargeable battery.

(a) Explain how shaking the torch produces an electric current.

(3)

(b) Explain, with reference to Lenz's law, how the magnet does work as it enters the coil.

(4)

(c) The circuit in the torch contains a diode between the coil and the battery.

Explain why the diode is needed if the battery is to charge.

(2)

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(Total for Question 15 = 9 marks)

Turn over

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16 According to Einstein's theory of relativity, the total energy E of a particle with rest mass m and momentum p is given by the equation

$$E^2 = m^2c^4 + p^2c^2$$

where c is the speed of light in a vacuum.

(a) Show that the base units on both sides of the equation are the same.

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(b) Simplify the equation for particles with zero velocity.

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(c) For particles with relativistic velocities, m^2c^4 is negligible compared to E^2 so the equation simplifies to

$$E = pc$$

Show that this is correct and that the simplification is justified for an electron of energy 45 GeV.

(4)

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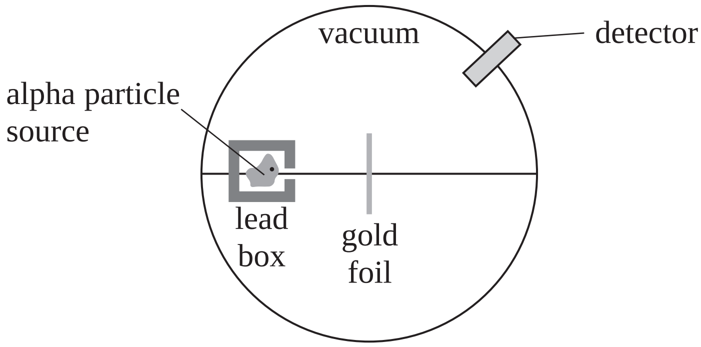
(Total for Question 16 = 9 marks)

17 In the early 1900s Geiger and Marsden carried out experiments in which a beam of high speed alpha particles was directed at thin gold foil.
The apparatus used is represented in the diagram.



(a) Explain why the alpha source was placed in a lead box with a single small hole.

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*(b) The following conclusions about atoms were made after the experiments.

1. The atom is mostly empty space.
2. The atom contains a small region of highly concentrated charge.
3. Most of the mass of the atom is concentrated in a very small space relative to the size of the atom.

Explain how the observations from the experiments led to these conclusions.

(6)

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(c) The source of alpha particles in some experiments was radium.

Complete the nuclear equation to show alpha decay for radium.

(2)

$$^{226}_{88}\text{Ra} \rightarrow {}^{\dots}_{\dots}\alpha + {}^{\dots}_{\dots}\text{Rn}$$

(d) An alpha particle has a speed of 1.50×10^7 m s^{-1}.

Determine the potential difference that would be required to bring it to rest. You may ignore relativistic effects at this speed.

mass of alpha particle = 4.00 u

(3)

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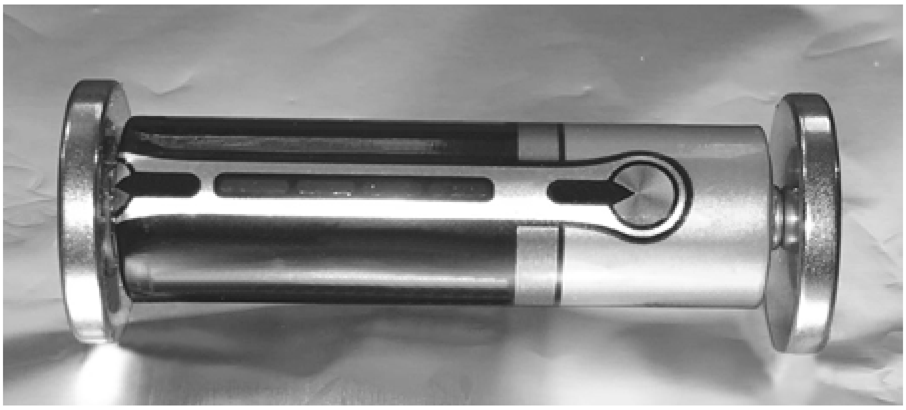
Potential difference = ...

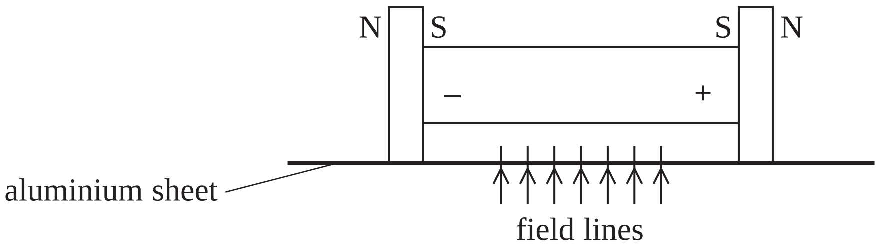
(Total for Question 17 = 13 marks)

18 The photograph shows an electric motor made by placing strong, circular, metallic magnets, with like poles facing each other, at either end of a dry cell.



When the motor is placed on an aluminium sheet, the motor begins to roll.

The magnets produce a magnetic field directly below the cell as shown.



*(a) Explain why the motor starts to roll when it is placed on the aluminium sheet.

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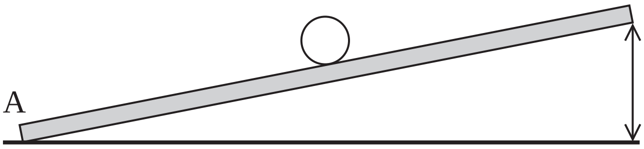
(b) To determine the magnitude of the force acting on the motor, the aluminium sheet is placed at an angle to the horizontal as shown. The motor is positioned to roll in the direction AB. The angle is varied until the motor does not roll up or down.



The motor remains stationary when B has been raised by 2.1 cm. The length of the sheet is 79.0 cm.

(i) Both measurements are made using a ruler marked in mm.

Compare this method of determining the angle, of about 1.5°, to measuring the angle with a protractor.

(3)

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(ii) Show that the force exerted on the motor is about 0.02 N.

mass of motor = 69.4 g

(3)

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(iii) Determine the magnitude of the magnetic flux density through the aluminium sheet. Assume the magnetic field is uniform along the length of the aluminium sheet between the magnets.

distance between magnets = 7.4 cm
current = 3.4 A

(2)

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Magnetic flux density = ...

(Total for Question 18 = 12 marks)

TOTAL FOR SECTION B = 70 MARKS
TOTAL FOR PAPER = 80 MARKS

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List of data, formulae and relationships

Acceleration of free fall	$g = 9.81\ \text{m s}^{-2}$	(close to Earth's surface)
Boltzmann constant	$k = 1.38 \times 10^{-23}\ \text{J K}^{-1}$	
Coulomb's law constant	$k = 1/4\pi\varepsilon_0$ $= 8.99 \times 10^{9}\ \text{N m}^2\ \text{C}^{-2}$	
Electron charge	$e = -1.60 \times 10^{-19}\ \text{C}$	
Electron mass	$m_e = 9.11 \times 10^{-31}\ \text{kg}$	
Electronvolt	$1\ \text{eV} = 1.60 \times 10^{-19}\ \text{J}$	
Gravitational constant	$G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$	
Gravitational field strength	$g = 9.81\ \text{N kg}^{-1}$	(close to Earth's surface)
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{F m}^{-1}$	
Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$	
Proton mass	$m_p = 1.67 \times 10^{-27}\ \text{kg}$	
Speed of light in a vacuum	$c = 3.00 \times 10^{8}\ \text{m s}^{-1}$	
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$	
Unified atomic mass unit	$u = 1.66 \times 10^{-27}\ \text{kg}$	

Unit 1

Mechanics

Kinematic equations of motion	$v = u + at$ $s = ut + \tfrac{1}{2}at^2$ $v^2 = u^2 + 2as$
Forces	$\Sigma F = ma$ $g = F/m$ $W = mg$
Work and energy	$\Delta W = F\Delta s$ $E_k = \tfrac{1}{2}mv^2$ $\Delta E_{grav} = mg\Delta h$

Materials

Stokes' law	$F = 6\pi\eta rv$
Hooke's law	$F = k\Delta x$
Density	$\rho = m/V$
Pressure	$p = F/A$
Young modulus	$E = \sigma/\varepsilon$ where Stress $\sigma = F/A$ Strain $\varepsilon = \Delta x/x$
Elastic strain energy	$E_{el} = \tfrac{1}{2}F\Delta x$

Unit 2

Waves

Wave speed $v = f\lambda$

Refractive index ${}_1\mu_2 = \sin i/\sin r = v_1/v_2$

Electricity

Potential difference $V = W/Q$

Resistance $R = V/I$

Electrical power, energy and efficiency
$P = VI$
$P = I^2R$
$P = V^2/R$
$W = VIt$

$$\%\ \text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \times 100$$

$$\%\ \text{efficiency} = \frac{\text{useful power output}}{\text{total power input}} \times 100$$

Resistivity $R = \rho l/A$

Current
$I = \Delta Q/\Delta t$
$I = nqvA$

Resistors in series $R = R_1 + R_2 + R_3$

Resistors in parallel $$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Quantum physics

Photon model $E = hf$

Einstein's photoelectric equation $hf = \phi + \frac{1}{2}mv^2_{max}$

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Unit 4

Mechanics

Momentum	$p = mv$
Kinetic energy of a non-relativistic particle	$E_k = p^2/2m$
Motion in a circle	$v = \omega r$ $T = 2\pi/\omega$ $F = ma = mv^2/r$ $a = v^2/r$ $a = r\omega^2$

Fields

Coulomb's law	$F = kQ_1Q_2/r^2$ where $k = 1/4\pi\varepsilon_0$
Electric field	$E = F/Q$ $E = kQ/r^2$ $E = V/d$
Capacitance	$C = Q/V$
Energy stored in capacitor	$W = \frac{1}{2}QV$
Capacitor discharge	$Q = Q_0 e^{-t/RC}$
In a magnetic field	$F = BIl \sin\theta$ $F = Bqv \sin\theta$ $r = p/BQ$
Faraday's and Lenz's laws	$\varepsilon = -\mathrm{d}(N\phi)/\mathrm{d}t$

Particle physics

Mass-energy	$\Delta E = c^2 \Delta m$
de Broglie wavelength	$\lambda = h/p$

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