NATIONAL JUNIOR COLLEGE

SENIOR HIGH 1 COMMON TEST

Higher 2

CANDIDATE NAME	

SUBJECT CLASS		REGISTRATION NUMBER	

PHYSICS **9749/01**

Paper 1 Multiple Choice

Candidate answers on the Question Paper.

30 September 2022

1 hour

No Additional Materials are required.

READ THESE INSTRUCTION FIRST

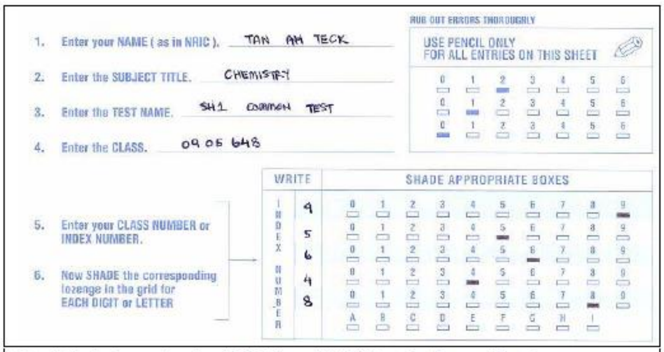
Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, subject class and registration number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

INSTRUCTIONS ON SHADING OF REGISTRATION NUMBER



Shade the index number in a 5 digit format (12345) on the Answer Sheet.

OAS index number is in 5-digit format.

5 digit format: **2nd digit** and the **last four digits** of the Reg Number.

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(1/(36\pi)) \times 10^{-9}\,\mathrm{F\,m^{-1}}$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass constant	$u = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

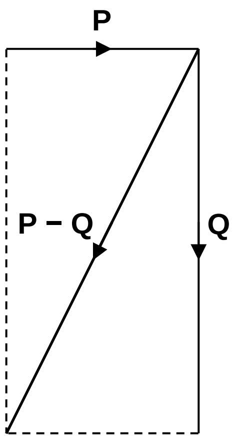
Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on / by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -Gm/r$
temperature	$T/\mathrm{K} = T/^\circ\mathrm{C} + 273.15$
pressure of an ideal gas	$p = \dfrac{1}{3}\dfrac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	$E = \dfrac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin\omega t$
velocity of particle in s.h.m.	$v = v_0 \cos\omega t$ $= \pm\,\omega\sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
alternating current / voltage	$x = x_0 \sin\omega t$
magnetic flux density due to a long straight wire	$B = \dfrac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \dfrac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{\ln 2}{t_{\frac{1}{2}}}$

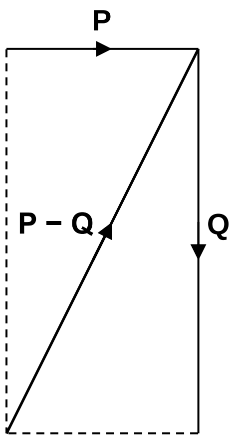
[Turn over

1 Which vector diagram shows the resultant of the vector subtraction **P − Q**?

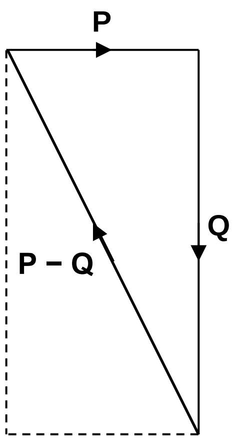
A



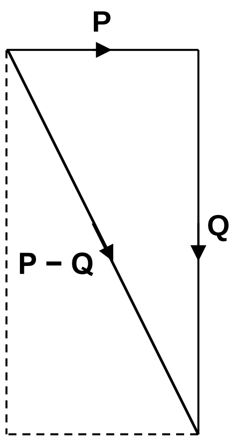
B



C



D



2 With regards to precision and accuracy, which of the following statements is true?

A A set of results with poor precision could be made more precise by removing the zero error.

B A set of results with poor accuracy could be made more accurate by taking the average of several readings.

C A set of results with good precision suggests that the mean value of the experiment is very close to the true value.

D A set of results with good accuracy suggests that there are little systematic errors in the experiment.

3 After taking measurements of the quantities in the expression $\frac{x^2 y}{z}$, the total percentage uncertainty is calculated as 6%.

Which individual percentage uncertainties of *x*, *y* and *z* when combined give this total of 6%?

	x / %	*y* / %	*z* / %
A	1	1	4
B	1	2	2
C	2	3	2
D	4	1	1

4 Two identical ball bearings are held at the same height above the ground. One bearing is released from rest. A short time later, the other bearing is released from rest. Air resistance is negligible.

As they fall, which of the following statements is true about the vertical distance between them?

A The distance will increase continuously.

B The distance will remain the same throughout.

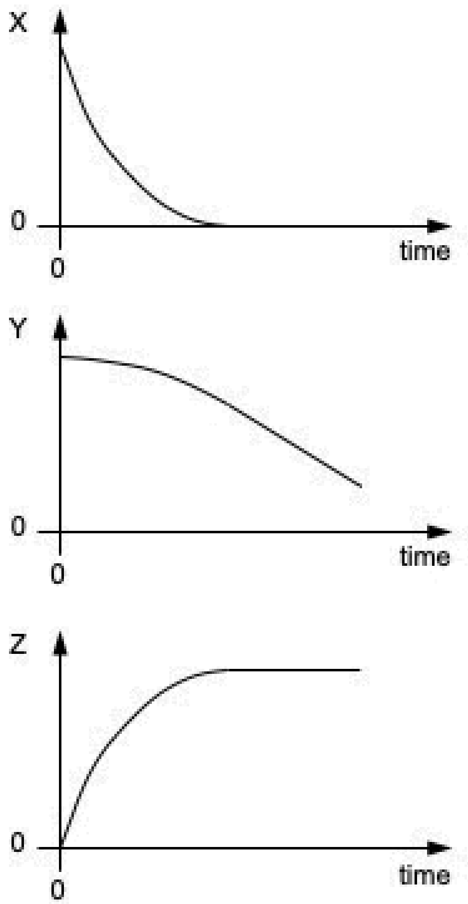
C The distance will increase initially then decrease.

D The distance will increase initially then remains constant.

5 An object is dropped at time $t = 0$ s from a tall building. Air resistance is significant.

Three quantities are plotted against time:

- height of object above ground
- speed of object
- magnitude of resultant force on object



What are the quantities X, Y and Z?

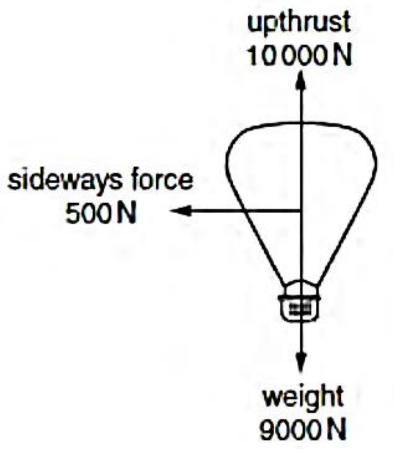
	height of object above ground	speed of object	magnitude of resultant force on object
A	X	Y	Z
B	X	Z	Y
C	Y	Z	X
D	Z	Y	X

6 An elevator is moving upwards with uniform upward acceleration of 5.8 m s^{-2}. A ball, held 2.0 m above the floor of the elevator, is released.

How long does it take for the ball to reach the floor of the elevator?

A 0.51 s **B** 0.64 s **C** 0.83 s **D** 1.00 s

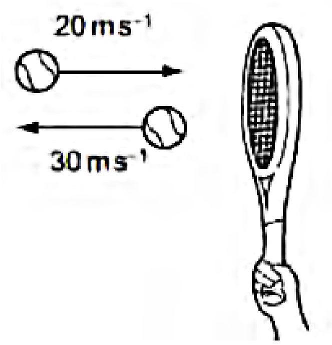
7 A balloon is acted upon by three forces, weight, upthrust and sideways force due to the wind, as shown in the diagram.



What is the rate of change of momentum of the balloon?

A 500 kg m s^{-2} **B** 1000 kg m s^{-2} **C** 1100 kg m s^{-2} **D** 1500 kg m s^{-2}

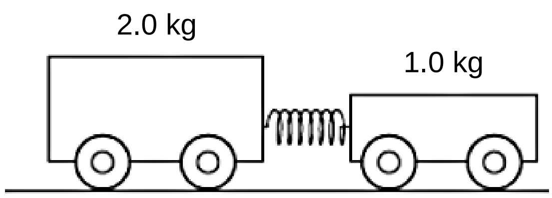
8 A tennis ball of mass 100 g is struck by a tennis racket. The velocity of the ball is changed as shown.



What is the magnitude of the impulse on the ball?

A 1.0 N s **B** 5.0 N s **C** 1000 N s **D** 5000 N s

9 Two trolleys are placed on a horizontal runway with a compressed spring between them.

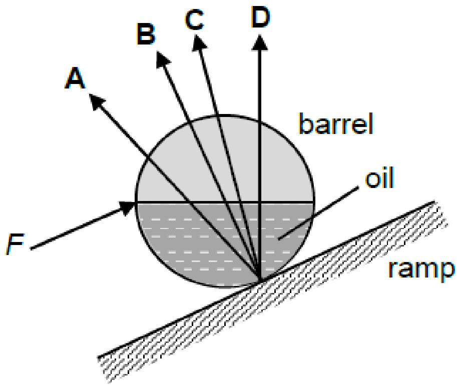


When they are released, the 2.0 kg trolley moves to the left at 2.0 m s^{-1}.

How much energy was stored in the spring?

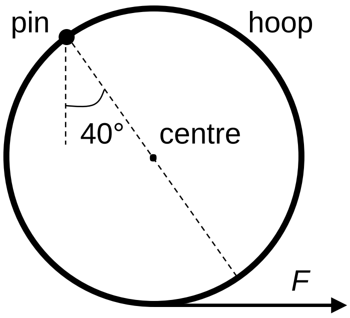
A 4.0 J **B** 6.0 J **C** 8.0 J **D** 12 J

10 A barrel half-filled with oil of uniform density is on a ramp as shown. The force *F* is applied in a direction parallel to the ramp such that the barrel is at rest.



Which arrow best represents the resultant force the ramp exerts on the barrel?

11 A uniform hoop of weight 20 N can rotate freely about a pin fixed to a wall.
The hoop is held in a vertical plane with its diameter at an angle of 40° to the vertical by a horizontal force *F*.



What is the value of *F*?

A 7.3 N **B** 7.8 N **C** 9.3 N **D** 71 N

12 Sand has higher density than cotton. 10.0 kg of sand and 10.0 kg of cotton are separately placed on the same sensitive mass balance in the same setup.

Which statement best describes the readings on the mass balance?

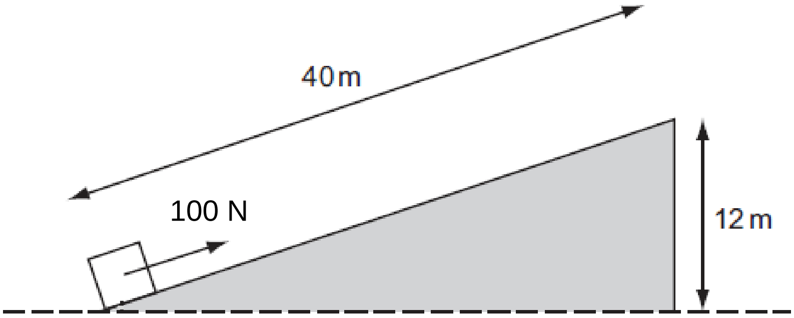
A The readings are the same.

B The reading for sand is larger than that for cotton.

C The reading for cotton is larger than that for sand.

D There is not enough information to make a comparison.

13 A constant force of 100 N, parallel to a rough inclined slope, moves a body of mass 20 kg at constant speed of 5.0 m s^{-1} through a distance of 40 m along the slope. The body gains a height of 12 m.

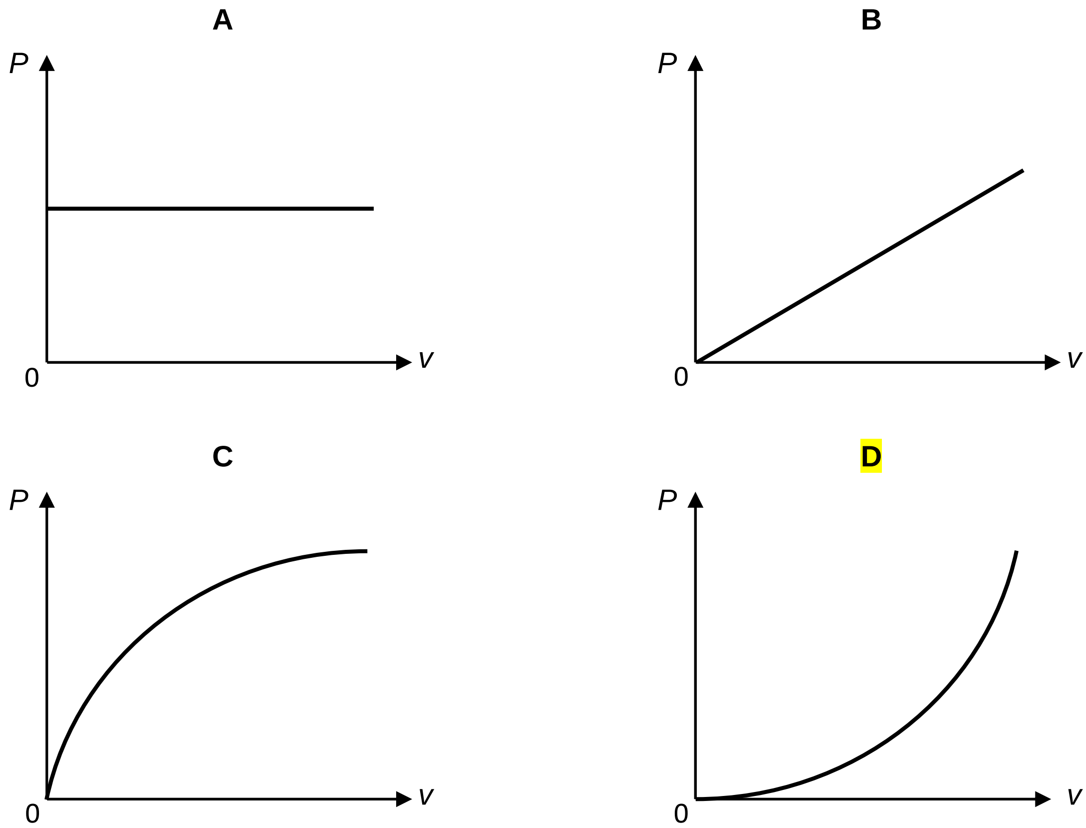


What is the magnitude of the work done by friction?

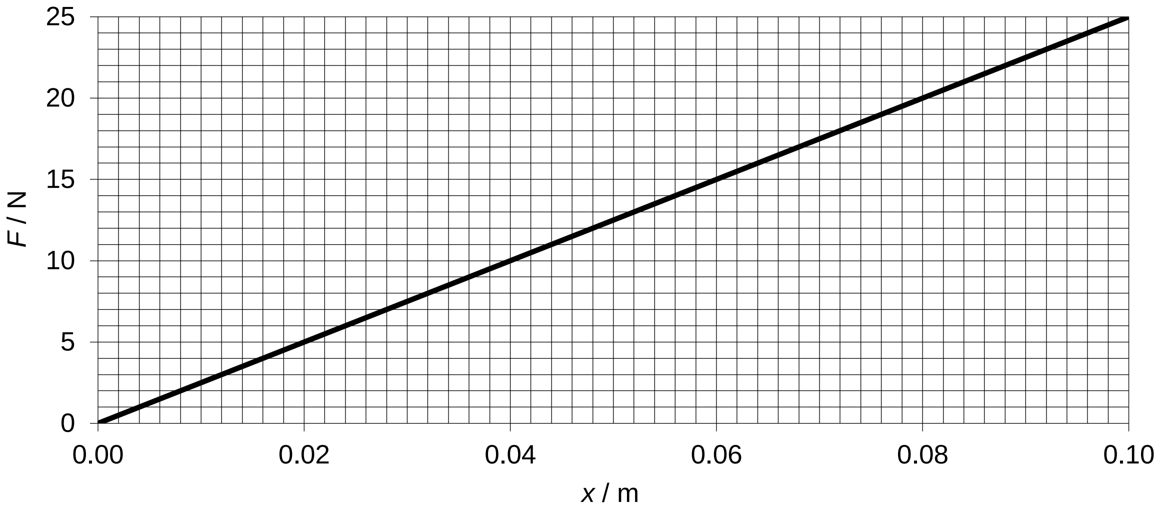
A 1.6 kJ **B** 2.4 kJ **C** 3.7 kJ **D** 4.0 kJ

14 A moving car experiences a resistive force *F* which is proportional to its velocity *v*.

Which of the following graphs shows the variation with *v* of the required power *P* supplied to the car?



15 The graph shows the variation with extension x of the load F on a certain spring.

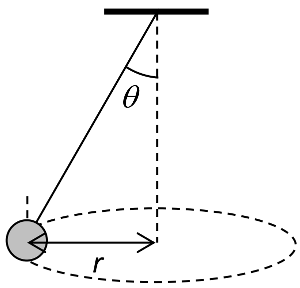


A load of 10 N is placed on the spring.

How much additional elastic potential energy will be stored in the spring if it is then extended a further 0.040 m?

A 0.200 J **B** 0.450 J **C** 0.600 J **D** 0.800 J

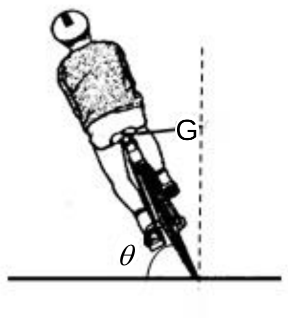
16 A metal bob is suspended with a light inextensible cord from the ceiling. It is set to whirl in a horizontal circle of radius r with a constant speed such that the cord is inclined at an angle θ to the vertical as shown in the diagram.



What is the period of rotation of the metal bob?

A $\sqrt{\dfrac{4\pi^2 r}{g}}$ **B** $\sqrt{\dfrac{4\pi^2 r}{g \sin\theta}}$ **C** $\sqrt{\dfrac{4\pi^2 r}{g \tan\theta}}$ **D** $\sqrt{\dfrac{4\pi^2}{rg \tan\theta}}$

17 A boy on a bicycle pedals around a circle of radius 30 m at a speed of 20 m s^{-1}. G is the centre of gravity of the boy and the bicycle. The line of action of the contact force between the ground and the bicycle passes through G. The combined mass of the boy and the cycle is 90 kg.



What is the angle θ that he makes with the horizontal?

A 13° **B** 36° **C** 54° **D** 86°

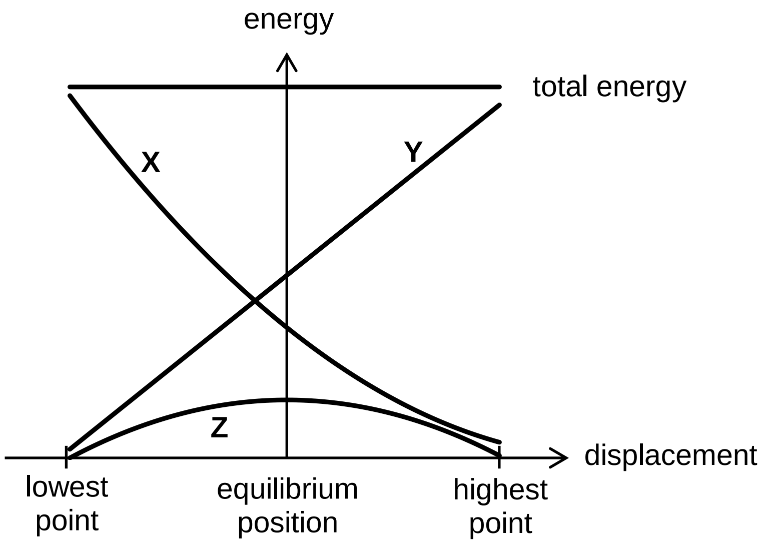
18 A pendulum bob of mass 1.27 kg is supported by an inextensible string 0.600 m long. It travels in a vertical circle.

The linear velocity of the bob at the bottom of the circle is 5.75 m s^{-1}.

What is the tension in the string when the bob is at the top of the circle?

A 7.69 N **B** 20.1 N **C** 70.0 N **D** 82.4 N

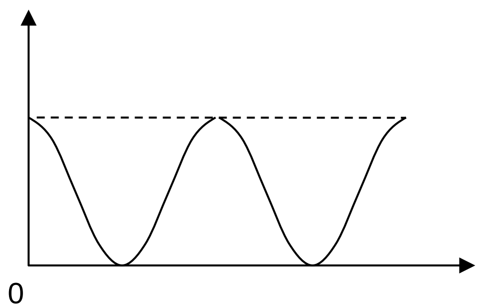
19 A mass attached to a spring is set into simple harmonic motion vertically. Interchange between kinetic energy, gravitational potential energy and elastic potential energy takes place throughout the oscillation. Three energy graphs X, Y and Z are plotted on the same axes below.



Which of the following combinations correctly identifies the graphs X, Y and Z?

	X	**Y**	**Z**
A	kinetic energy	elastic potential energy	gravitational potential energy
B	gravitational potential energy	kinetic energy	elastic potential energy
C	gravitational potential energy	elastic potential energy	kinetic energy
D	elastic potential energy	gravitational potential energy	kinetic energy

20 The diagram below shows one possible graph for an object undergoing simple harmonic motion.



Which quantities could have been plotted to produce this graph?

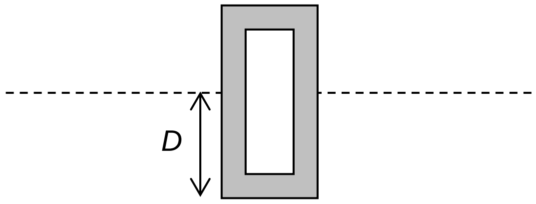
A velocity and time

B velocity and displacement

C kinetic energy and time

D kinetic energy and displacement

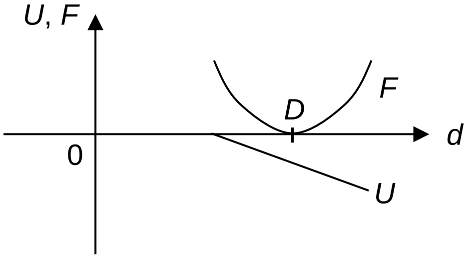
21 A hollow metal cylinder floats upright in a body of water with the bottom of the cylinder at a depth of *D* below the water surface as shown in the figure below.



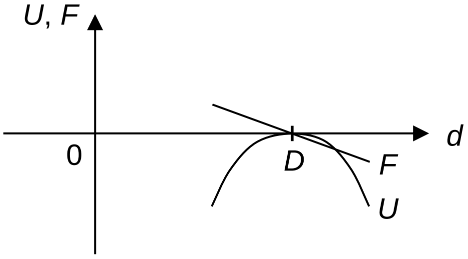
The cylinder is pressed further down into the water and upon release, performs simple harmonic motion.

Which of the following graphs (all drawn to scale) shows how the upthrust *U* and net force *F* acting on the cylinder vary with *d*, the depth the bottom of the cylinder below the water surface?

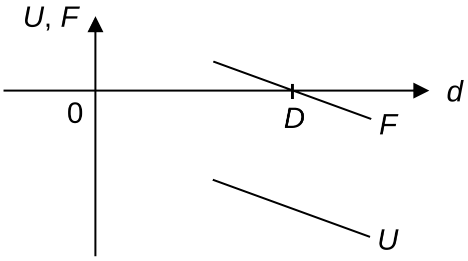
A



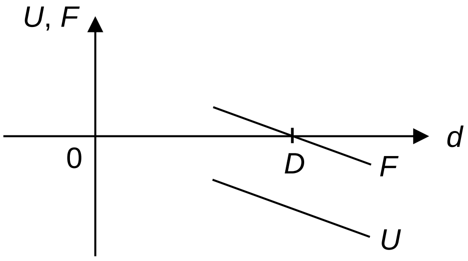
B



C

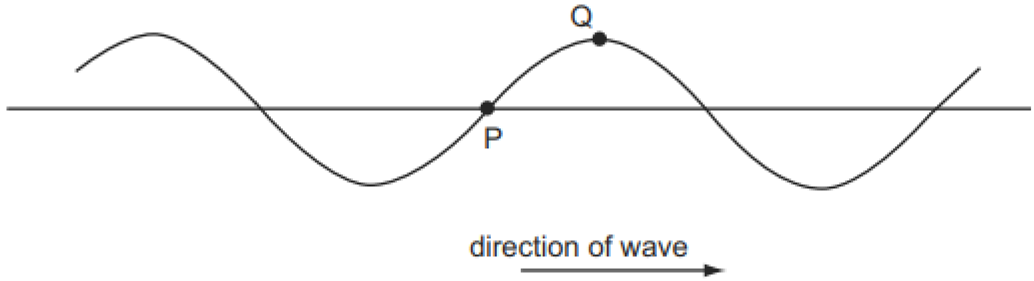


D



22 The diagram shows a transverse wave on a rope. The wave is travelling from left to right.

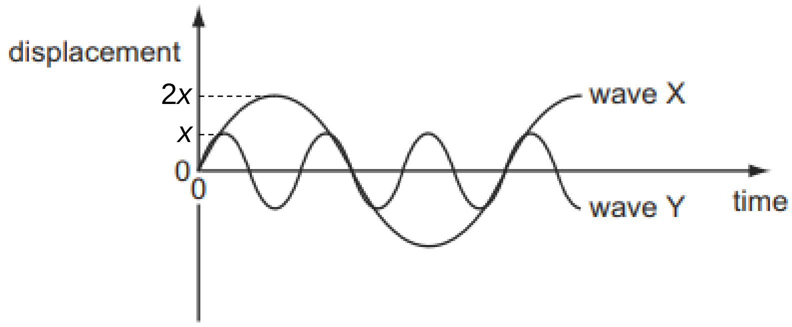
At the instant shown, the points P and Q on the rope have zero displacement and maximum displacement respectively.



Which of the following describes the motion, if any, of the points P and Q at this instant?

	point P	point Q
A	upwards	stationary
B	stationary	upwards
C	stationary	downwards
D	downwards	stationary

23 The intensity of a progressive wave is proportional to the square of the frequency of the wave. The diagram shows two waves X and Y.

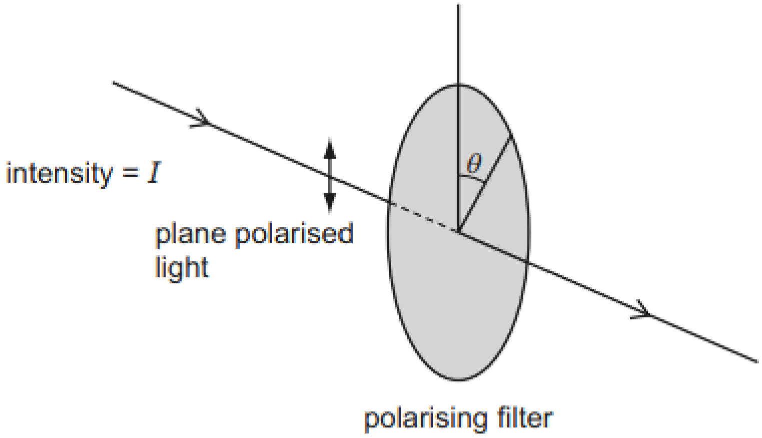


The intensity of wave X is I.

What is the intensity of wave Y?

A $\frac{1}{4}I$ **B** $\frac{1}{2}I$ **C** $\frac{9}{4}I$ **D** $9I$

24 Plane-polarised light of intensity I is passed through a polarising filter.



θ is the angle between the plane of polarisation of the incident light and the polarisation axis of the polarising filter.

What is the intensity of the emerging light when $\theta = 60.0°$?

A 0.250 I **B** 0.500 I **C** 0.750 I **D** 0.866 I

25 Three telescopes with apertures of different diameters are designed to observe an astronomical object at different wavelengths as shown below.

telescope	diameter / m	observation wavelength / nm
(i)	1.0	500
(ii)	2.0	100
(iii)	3.0	1000

Which of the following ranks the telescopes from the one with the worst resolution to the one with the best resolution?

A (i), (ii), (iii) **B** (i), (iii), (ii) **C** (ii), (iii), (i) **D** (iii), (ii), (i)

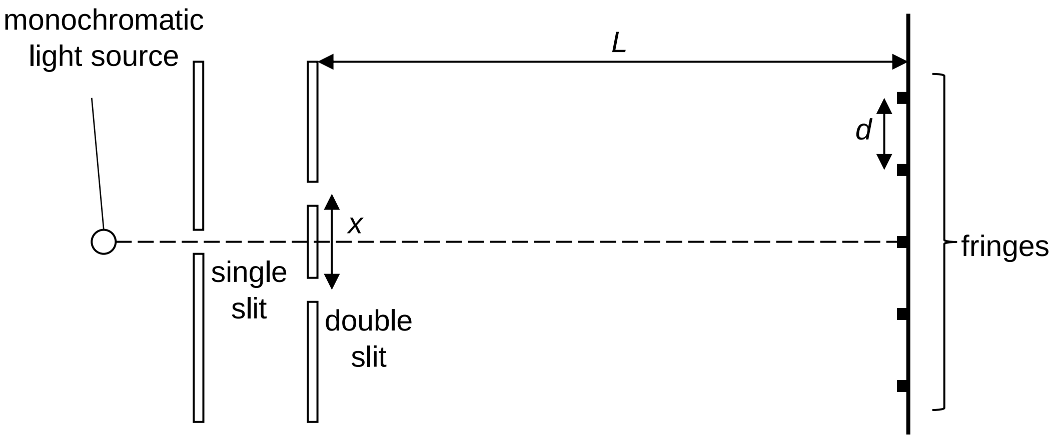
26 Two stars X and Y with a small angular displacement θ emit light of wavelength λ.
The two stars are just resolved when observed with a particular telescope.
Another pair of stars is viewed using the same telescope.

Which of the following pair of stars can **definitely** be distinguished?

pair	angular displacement between pair of stars compared to θ	wavelength of light from pair of stars compared to λ
A	smaller	same
B	same	longer
C	smaller	shorter
D	same	shorter

[Turn over

27 A double slit experiment is shown below. The light source has wavelength λ, the slit separation is x, the fringe separation is d and the distance between the slits and screen is L.



The wavelength is increased to 2λ, the slit separation is increased to $4x$ and the distance between the slits and the screen is decreased to $\frac{1}{2}L$.

What is the resulting fringe separation?

A $0.25d$ **B** $0.50d$ **C** $2.0d$ **D** $4.0d$

28 Which quantity is **not necessarily** the same for satellites in geostationary orbits around the Earth?

A angular velocity

B centripetal acceleration

C kinetic energy

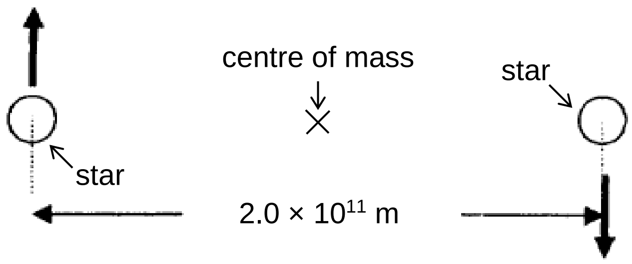
D orbital period

29 An astronaut is at a distance above the Earth equal to the radius of the Earth.

If the gravitational field strength at the surface of the earth is g, what is her acceleration due to gravity?

A zero **B** $\frac{g}{4}$ **C** $\frac{g}{2}$ **D** g

30 A binary star system consists of two stars, each of mass 4.0×10^{30} kg, separated by a distance of 2.0×10^{11} m. The stars rotate about the centre of mass of the system.



What is the period of rotation of each star?

A 1.2×10^7 s **B** 1.7×10^7 s **C** 2.4×10^7 s **D** 3.4×10^7 s

END OF PAPER

2022 SH1 H2 Physics (9749)
Promotional Examination Paper 1

Answers

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
B	D	B	A	B	A	C	B	D	C	A	B	A	D	C
16	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
C	B	A	D	C	D	D	C	A	B	D	A	C	B	C

Workings/Explanations

1	**P − Q = P + (−Q)** **P** is rightwards. **−Q** is upwards. **P − Q** is diagonally rightward and upward.
2	Accuracy is related to systematic error and Precision is related to random error. Having little systematic error means that the results are accurate. Why A is wrong – Removing systematic error such as zero error improves accuracy. Why B is wrong – Taking the mean value of the experiment reduces random error and improve precision and does not affect the accuracy. Why C is wrong – If mean value is close to the true value, then it is accurate.
3	2(1%) + 2% + 2% = 6%
4	The first ball bearing always has a larger speed than the second, so the distance between them keeps increasing.
5	height of object above ground – always decreasing (with decreasing gradient) until reaches constant negative gradient at terminal velocity therefore Y speed of object – starts from zero always increasing until remain constant at terminal velocity therefore Z magnitude of resultant force on object – decreasing (due to air resistance increasing and weight remaining constant) until reaches zero at terminal velocity therefore X
6	Let initial velocity of elevator be *u* (so it is the same for the ball). At time *t* the ball hits the floor of elevator. For ball: $s_{\text{ball}} = ut - \frac{1}{2}gt^2$ (this is the displacement from its initial position) For floor: $s_{\text{floor}} = ut + \frac{1}{2} \times 5.8t^2$ When they meet, taking reference from the floor as the initial position, (since ball is 2.0 m above floor, it has an initial displacement of 2.0 m) $s_{\text{floor}} = s_{\text{ball}} + 2.0$ $ut + \frac{1}{2} \times 5.8t^2 = ut - \frac{1}{2} \times 9.81t^2 + 2.0$ $t = 0.51$ s
7	rate of change of momentum = resultant force = $\sqrt{(10000 - 9000)^2 + 500^2}$ = 1100 kg m s^{-2}
8	impulse = change in momentum = 0.100 (−30 − 20) = −5.0 N s

9	linear momentum of 2.0 kg trolley = 2.0 (2.0) = 4.0 kg m s^{-1} (left) therefore linear momentum of 1.0 kg trolley is 4.0 kg m s^{-1} (right) by Conservation of Linear Momentum since Initial Total Linear Momentum is zero therefore speed of 1.0 kg trolley = 4.0 m s^{-1} energy stored in spring = Total final kinetic energy = ½ (2.0)$(2.0)^2$ + ½ (1.0)$(4.0)^2$ = 12 J
10	The lines of action of *F*, the weight of the barrel and the resultant force of the ramp must meet at a common point so that resultant moment about that point is zero. The three forces will also form a closed vector triangle to ensure resultant force acting on the barrel is zero.
11	Take moments about the pin: Anti-clockwise moment = Clockwise moment $F \times \left(r + r\cos 40^\circ\right) = 20 \times r\sin 40^\circ$ *F* = 7.3 N
12	The same mass of sand displaces a smaller volume of air. Upthrust on sand is less than that for cotton. Contact force + upthrust = weight Contact force on the balance is larger for sand, so its reading is larger.
13	Total work done = $100 \times 40 = 4000$ J Gain in gravitational potential energy = $mgh = 20.0 \times 9.81 \times 12 = 2354$ J Work done against friction = work done by friction = $4000 - 2354 = 1645$ J
14	At (constant maximum) velocity, driving force of the car = resistive force = kv The required power for (constant maximum) velocity = $Fv = kv^2$
15	From graph, extension with 10 N load = 0.040 m Therefore area under graph from 0.040 m to 0.080 m = ½(10+20)(0.080 − 0.040) = 0.600 J OR Elastic potential energy with 10 N load = ½kx^2 = ½(10/0.040)$(0.040)^2$ = 0.200 J Elastic potential energy at additional 0.040 m extension = ½(10/0.040)$(0.080)^2$ = 0.800 J Additional elastic potential energy = 0.800 − 0.200 = 0.600 J
16	Horizontally: $P\sin\theta = mr\omega^2$ where tension: P Vertically: $P\cos\theta = mg$ Hence, $\tan\theta = \dfrac{r\omega^2}{g} = \dfrac{r}{g}\left(\dfrac{4\pi^2}{T^2}\right) \Rightarrow T = \sqrt{\dfrac{4\pi^2 r}{g\tan\theta}}$
17	Let the magnitude of the contact force be *F* Vertical component of contact force *F* balances weight $F\sin\theta = mg \ldots (1)$ Horizontal component of *F* provides centripetal force $F\cos\theta = \dfrac{mv^2}{r} \ldots (2)$ $\dfrac{(1)}{(2)} : \tan\theta = \dfrac{gr}{v^2} = \dfrac{9.81(30)}{20^2} = 0.73575$ $\theta = \tan^{-1}(0.73575) = 36°$

18	KE at top of circle $=$ KE at bottom of circle-gain in GPE $=\frac{1}{2}(1.27)(5.75^2)-(1.27)(9.81)(1.2)$ $=6.044$ J Linear speed at top of circle: $\frac{1}{2}mv^2=6.044$ $v=3.085$ m s^{-1} Tension at top, $T=F_C-mg$ $=\frac{(1.27)(3.085^2)}{0.6}-(1.27)(9.81)$ $=7.689$ ≈ 7.69 N
19	Elastic potential energy is proportional to the square of the extension of the spring. Gravitational potential energy (near the surface of the Earth) is proportional to vertical distance. Kinetic energy is zero at the extreme ends of the oscillation and maximum at the equilibrium.
20	A is wrong as velocity cannot be positive all the time. B and D are wrong because the shape of the graphs are different. Only C is possible. Kinetic energy and time will have a graph similar to a $\sin^2(\omega t)$ or $\cos^2(\omega t)$ graph, although the graph may be shifted.
21	$F = W + U$ At $d = D$, $F = 0$ (equilibrium) Since W is a positive constant (taking downwards as positive), F is parallel to U and is shifted upwards from U $U = -\rho gV = -\rho gA\ d$ (Note: U is upwards hence negative. ρ, g and A are constants.) U-d graph is downward sloping straight line (constant gradient) and passes through the origin (extend the U line to check that it passes through the origin)
22	Point Q is momentarily stationary when maximum displacement. Point P is moving downwards which can be seen if we imagine the wave to have moved to the right a short time later.
23	$T_X = 3T_Y$ hence $T_Y = \frac{1}{3}T_X$ $$f_Y = \frac{1}{T_Y} = \frac{1}{\frac{1}{3}T_X} = \frac{3}{T_X} = 3f_X$$ $$A_Y = \frac{1}{2}A_X$$ Since $I \propto f^2$ and $I \propto A^2$, $I = kf^2A^2$ $$I_X = I = k{f_X}^2{A_X}^2$$ $$I_Y = k{f_Y}^2{A_Y}^2 = k(3f_X)^2\left(\frac{1}{2}A_X\right)^2 = \frac{9}{4}k{f_X}^2{A_X}^2 = \frac{9}{4}I$$
24	Malus' Law, $I' = I\cos^2 60.0° = 0.250\ I$

<table>
<tr><td>25</td><td>Using Rayleigh’s criterion, $\theta_R \approx \frac{\lambda}{d}$
The smaller the value of θ_R, the better the resolution because smaller details can be resolved.
Therefore, the telescope with the best resolution is the telescope with the smallest ratio of $\frac{\lambda}{d}$.
<table>
<tr><th>telescope</th><th>λ/d</th><th>resolution</th></tr>
<tr><td>(i)</td><td>5.0×10^{-7}</td><td>Worst</td></tr>
<tr><td>(ii)</td><td>5.0×10^{-8}</td><td>Best</td></tr>
<tr><td>(iii)</td><td>3.3×10^{-7}</td><td></td></tr>
</table>
Hence, in the order from the worst resolution to the best resolution, it will be (i), (iii), (ii).</td></tr>
<tr><td>26</td><td>Angular displacement cannot be smaller (either same or larger) as smaller means they are closer and therefore more difficult to distinguish.
Wavelength cannot be longer (either same or shorter) as longer wavelength means the minimum angular displacement at which they can be distinguished is larger.</td></tr>
<tr><td>27</td><td>$d = \frac{\lambda L}{x}$
$d_{\text{new}} = \frac{(2\lambda)(0.5L)}{4x} = 0.25\frac{\lambda L}{x} = 0.25d$</td></tr>
<tr><td>28</td><td>Geo-stationary satellite has the same period as the period of 24 hours.
Same period also means same angular velocity.
Kepler’s Law states that for a given period the distance is fixed. So the centripetal acceleration is also the same.
Kinetic energy may be different as different satellite may have different mass.</td></tr>
<tr><td>29</td><td>$g = \frac{GM}{R^2}$
$\frac{g_{2R}}{g_R} = \frac{R^2}{(2R)^2}$
$\frac{g_{2R}}{g} = \frac{R^2}{4R^2}$
$g_{2R} = \frac{1}{4}g$</td></tr>
<tr><td>30</td><td>$\frac{GMm}{r^2} = mr'(\frac{2\pi}{T})^2$
$\frac{G(4.0 \times 10^{30})}{(2.0 \times 10^{11})^2} = (1.0 \times 10^{11})(\frac{2\pi}{T})^2$
$T = 2.4 \times 10^7$ s</td></tr>
</table>