1 A particle travels at a constant speed around a circle of radius *r* with centripetal acceleration *a*. What is the time taken for ten complete rotations?

A $\frac{\pi}{5}\sqrt{\frac{a}{r}}$

B $\frac{\pi}{5}\sqrt{\frac{r}{a}}$

C $20\pi\sqrt{\frac{a}{r}}$

D $20\pi\sqrt{\frac{r}{a}}$

(Total 1 mark)

2 The frequency of a body moving with simple harmonic motion is doubled. If the amplitude remains the same, which one of the following is also doubled?

A the time period

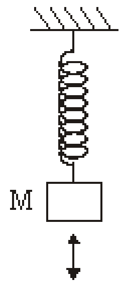
B the total energy

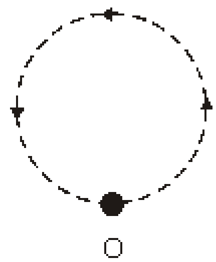
C the maximum velocity

D the maximum acceleration

(Total 1 mark)

3 A mass M on a spring oscillates along a vertical line with the same period T as an object O in uniform circular motion in a vertical plane. When M is at its highest point, O is at its lowest point.





What is the least time interval between successive instants when the acceleration of M is exactly in the opposite direction to the acceleration of O?

A $\frac{T}{4}$

B $\frac{T}{2}$

C $\frac{3T}{4}$

D T

(Total 1 mark)

4 A particle of mass m oscillates with amplitude A at frequency f. What is the maximum kinetic energy of the particle?

A $\frac{1}{2}\pi^2 mf^2A^2$

B $\pi^2 mf^2A^2$

C $2\pi^2 mf^2A^2$

D $4\pi^2 mf^2A^2$

(Total 1 mark)

5 For a particle moving in a circle with uniform speed, which **one** of the following statements is correct?

A The displacement of the particle is in the direction of the force.

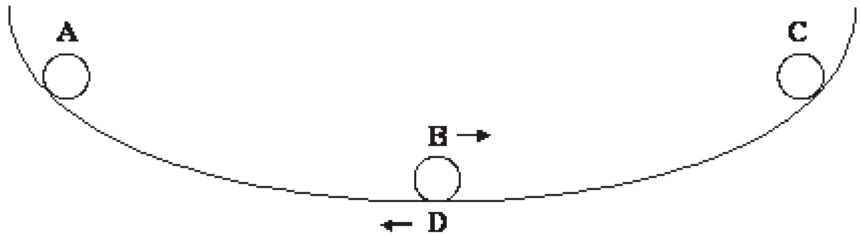
B The force on the particle is in the same direction as the direction of motion of the particle.

C The momentum of the particle is constant.

D The kinetic energy of the particle is constant.

(Total 1 mark)

6 A ball bearing rolls on a concave surface, as shown in the diagram, in approximate simple harmonic motion. It is released from **A** and passes through the lowest point **B** before reaching **C**. It then returns through the lowest point **D**. At which stage, **A**, **B**, **C** or **D**, does the ball bearing experience maximum acceleration to the left?



(Total 1 mark)

7 A body moves with simple harmonic motion of amplitude *A* and frequency $\frac{b}{2\pi}$.

What is the magnitude of the acceleration when the body is at maximum displacement?

A zero

B $4\pi^2Ab^2$

C Ab^2

D $\frac{4\pi^2A}{b^2}$

(Total 1 mark)

8 What is the value of the angular velocity of a point on the surface of the Earth?

A 1.2×10^{-5} rad s^{-1}

B 7.3×10^{-5} rad s^{-1}

C 2.6×10^{-1} rad s^{-1}

D 4.6×10^{2} rad s^{-1}

(Total 1 mark)

9 A spring is suspended from a fixed point. A mass attached to the spring is set into vertical undamped simple harmonic motion. When the mass is at its lowest position, which one of the following has its minimum value?

A the potential energy of the system

B the kinetic energy of the mass

C the acceleration of the mass

D the tension in the spring

(Total 1 mark)

10 The time period of a simple pendulum is doubled when the length of the pendulum is increased by 3.0 m. What is the original length of the pendulum?

A 1.0 m

B 1.5 m

C 3.0 m

D 6.0 m

(Total 1 mark)

11 A particle of mass *m* moves in a circle of radius *r* at uniform speed, taking time *T* for each revolution. What is the kinetic energy of the particle?

A $\frac{\pi^2 m r}{T^2}$

B $\frac{\pi^2 m r^2}{T^2}$

C $\frac{2\pi^2 m r^2}{T}$

D $\frac{2\pi^2 m r^2}{T^2}$

(Total 1 mark)

12 A mass on the end of a string is whirled round in a horizontal circle at increasing speed until the string breaks. The subsequent path taken by the mass is

A a straight line along a radius of the circle.

B a horizontal circle.

C a parabola in a horizontal plane.

D a parabola in a vertical plane.

(Total 1 mark)

13 Which one of the following statements always applies to a damping force acting on a vibrating system?

A It is in the same direction as the acceleration.

B It is in the opposite direction to the velocity.

C It is in the same direction as the displacement.

D It is proportional to the displacement.

(Total 1 mark)

14 A particle of mass m moves in a circle of radius r at a uniform speed with frequency f. What is the kinetic energy of the particle?

A $\frac{mf^2r^2}{4\pi^2}$

B $\frac{mf^2r}{2}$

C $2\pi^2mf^2r^2$

D $4\pi^2mf^2r^2$

(Total 1 mark)

15 A body is in simple harmonic motion of amplitude 0.50 m and period 4π seconds. What is the speed of the body when the displacement of the body is 0.30 m?

A $0.10\ \text{m s}^{-1}$

B $0.15\ \text{m s}^{-1}$

C $0.20\ \text{m s}^{-1}$

D $0.40\ \text{m s}^{-1}$

(Total 1 mark)

16 Which one of the following statements about an oscillating mechanical system at resonance, when it oscillates with a constant amplitude, is **not** correct?

A The amplitude of oscillations depends on the amount of damping.

B The frequency of the applied force is the same as the natural frequency of oscillation of the system.

C The total energy of the system is constant.

D The applied force prevents the amplitude from becoming too large.

(Total 1 mark)

17 What is the angular speed of a point on the Earth's equator?

A 7.3×10^{-5} rad s^{-1}

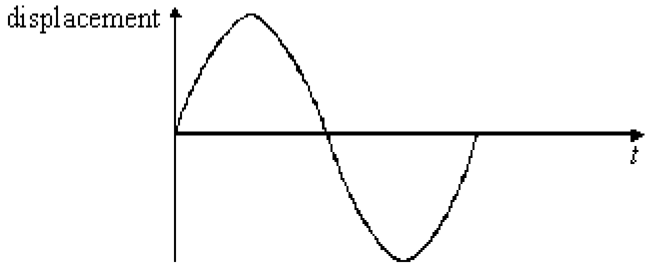
B 4.2×10^{-3} rad s^{-1}

C 2.6×10^{-1} rad s^{-1}

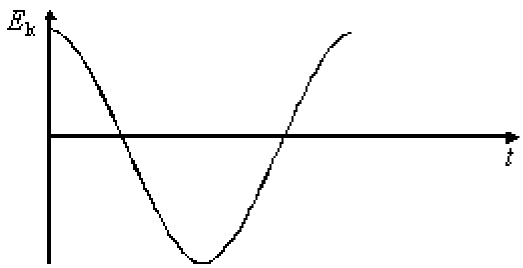
D 15 rad s^{-1}

(Total 1 mark)

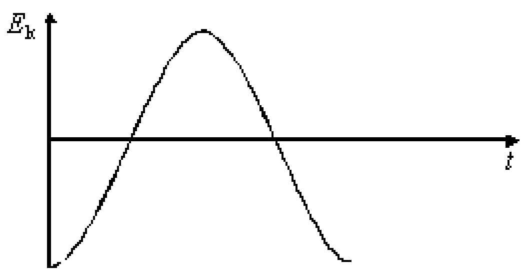
18 The top graph is a displacement/time graph for a particle executing simple harmonic motion. Which one of the other graphs shows correctly how the kinetic energy, E_k, of the particle varies with time?



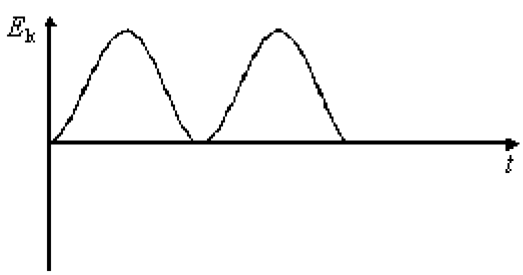
A



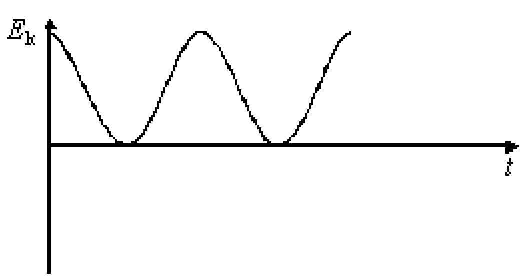
B



C



D



(Total 1 mark)

19 To find a value for the acceleration of free fall, g, a student measured the time of oscillation, T, of a simple pendulum whose length, l, is changed. The student used the results to plot a graph of T^2 (y axis) against l (x axis) and found the slope of the line to be S. It follows that g is

A $\frac{4\pi^2}{S}$.

B $4\pi^2 S$.

C $\frac{2\pi}{S}$.

D $2\pi S$.

(Total 1 mark)

20 A body moves in simple harmonic motion of amplitude 0.90 m and period 8.9 s. What is the speed of the body when its displacement is 0.70 m?

A 0.11 m s^{-1}

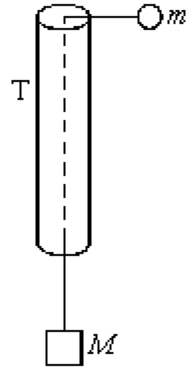
B 0.22 m s^{-1}

C 0.40 m s^{-1}

D 0.80 m s^{-1}

(Total 1 mark)

21



The figure shows a smooth thin tube T through which passes a string with masses *m* and *M* attached to its ends. Initially the tube is moved so that the mass, *m*, travels in a horizontal circle of constant radius *r*, at constant speed, *v*. Which one of the following expressions is equal to *M*?

A $\frac{mv^2}{2r}$

B mv^2rg

C $\frac{mv^2g}{r}$

D $\frac{mv^2}{rg}$

(Total 1 mark)

22 An object moving at constant speed in a circle experiences a force that is

A in the direction of motion.

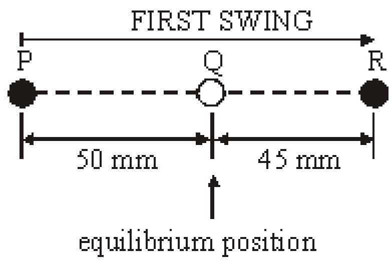
B outwards and at right angles to the direction of motion.

C inwards and at right angles to the direction of motion.

D opposite to the direction of motion.

(Total 1 mark)

23 A particle, whose equilibrium position is at Q, is set into oscillation by being displaced to P, 50 mm from Q, and then released from rest. Its subsequent motion is simple harmonic, but subject to damping. On the first swing, the particle comes to rest momentarily at R, 45 mm from Q.



During this first swing, the greatest value of the acceleration of the particle is when it is at

A P.

B Q.

C R.

D P and R.

(Total 1 mark)

24 A particle of mass 5.0×10^{-3} kg performing simple harmonic motion of amplitude 150 mm takes 47 s to make 50 oscillations. What is the maximum kinetic energy of the particle?

A 2.0×10^{-3} J

B 2.5×10^{-3} J

C 3.9×10^{-3} J

D 5.0×10^{-3} J

(Total 1 mark)

25 When the length of a simple pendulum is decreased by 600 mm, the period of oscillation is halved. What is the original length of the pendulum?

A 800 mm

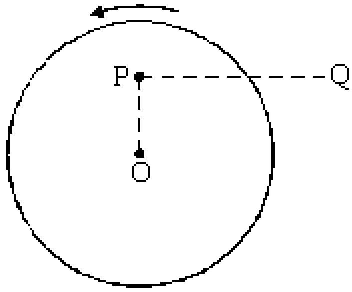
B 1000 mm

C 1200 mm

D 1400 mm

(Total 1 mark)

26



A small mass is placed at P on a horizontal disc which has centre O. The disc rotates anti-clockwise about a vertical axis through O with constant angular speed. Which one of the following describes the force which keeps the mass at rest relative to the disc?

A the weight of the mass

B a frictional force directed away from O

C a frictional force directed towards O

D a frictional force directed from P to Q

(Total 1 mark)

27 A fairground roundabout makes nine revolutions in one minute. What is the angular speed of the roundabout?

A 0.15 rad s^{-1}

B 0.34 rad s^{-1}

C 0.94 rad s^{-1}

D 2.1 rad s^{-1}

(Total 1 mark)

28 Which one of the following gives the phase difference between the particle velocity and the particle displacement in simple harmonic motion?

A $\frac{\pi}{4}$ rad

B $\frac{\pi}{2}$ rad

C $\frac{3\pi}{4}$ rad

D 2π rad

(Total 1 mark)

29 A particle oscillates with undamped simple harmonic motion. Which one of the following statements about the acceleration of the oscillating particle is true?

A It is least when the speed is greatest.

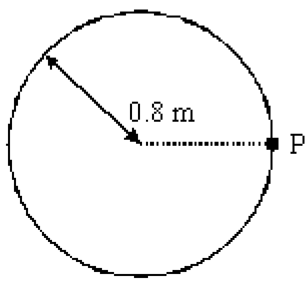
B It is always in the opposite direction to its velocity.

C It is proportional to the frequency.

D It decreases as the potential energy increases.

(Total 1 mark)

30



A model car moves in a circular path of radius 0.8 m at an angular speed of $\frac{\pi}{2}$ rad s^{-1}.

What is its displacement from point P, 6 s after passing P?

A zero

B 1.6 m

C 0.4π m

D 1.6π m

(Total 1 mark)

31 A mass M hangs in equilibrium on a spring. M is made to oscillate about the equilibrium position by pulling it down 10 cm and releasing it. The time for M to travel back to the equilibrium position for the first time is 0.50 s. Which line, **A** to **D**, is correct for these oscillations?

	amplitude/cm	period/s
A	10	1.0
B	10	2.0
C	20	2.0
D	20	1.0

(Total 1 mark)

32 Which one of the following statements is true when an object performs simple harmonic motion about a central point O?

A The acceleration is always away from O.

B The acceleration and velocity are always in opposite directions.

C The acceleration and the displacement from O are always in the same direction.

D The graph of acceleration against displacement is a straight line.

(Total 1 mark)

33 A girl of mass 40 kg stands on a roundabout 2.0 m from the vertical axis as the roundabout rotates uniformly with a period of 3.0 s. The horizontal force acting on the girl is approximately

A zero.

B 3.5×10^2 N.

C 7.2×10^2 N.

D 2.8×10^4 N.

(Total 1 mark)

34 For a particle moving in a circle with uniform speed, which one of the following statements is **incorrect**?

A The velocity of the particle is constant.

B The force on the particle is always perpendicular to the velocity of the particle.

C There is no displacement of the particle in the direction of the force.

D The kinetic energy of the particle is constant.

(Total 1 mark)

35 A simple pendulum and a mass-spring system are taken to the Moon, where the gravitational field strength is less than on Earth. Which line, **A** to **D**, correctly describes the change, if any, in the period when compared with its value on Earth?

	period of pendulum	period of mass−spring system
A	decrease	decrease
B	increase	increase
C	no change	decrease
D	increase	no change

(Total 1 mark)

Mark schemes

1 D **[1]**

2 C **[1]**

3 B **[1]**

4 C **[1]**

5 D **[1]**

6 C **[1]**

7 C **[1]**

8 B **[1]**

9 B **[1]**

10 A **[1]**

11 D **[1]**

12 D **[1]**

13 B **[1]**

14 C **[1]**

15 C **[2]**

16 D **[2]**

17 A **[1]**

18 D **[1]**

19 A **[1]**

20 C **[1]**

21 D **[1]**

22 C **[1]**

23 A **[1]**

24 B **[1]**

25 A **[1]**

26 C **[1]**

27 C **[1]**

28 B **[1]**

29 A **[1]**

30 B **[1]**

31 B **[1]**

32 D **[1]**

33 B **[1]**

34 A **[1]**

35 D **[1]**

Examiner reports

1 This question was a sterner test of motion in a circle, because it was a two-stage calculation with algebraic distractors. Just over half of the candidates arrived at the correct result by combining $a = v^2/r$ and $T = 2\pi r/v$. Almost a quarter of the responses were for distractor C, in which the squarerooted expression (r /a) is inverted. This is likely to have been caused by careless rearrangement of the algebra.

2 Simple harmonic oscillation was the topic tested by this question (which had been used before). 79% of the responses were correct, which was 8% better than when it was last used. This shows that vmax = 2πfA is well known.

3 This question invited candidates to compare the accelerations of a mass in shm and an object in uniform circular motion. 67% of the candidates recognised that these accelerations would have opposite directions at time intervals of 772, but almost one fifth of them thought it would be 774. This question was not very successful at discriminating between more and less able candidates.

4 Application of $½mv^2$, together with $v_{max} = 2\pi fA$, readily gave the correct response for 70% of the candidates in this question; this was a much higher percentage than that achieved when the question was pre-tested. The most common wrong response was distractor D, no doubt chosen by those who overlooked the factor of ½.

5 This question tested candidates' understanding of some of the features of uniform circular motion. Just over half of the candidates realised that a particle moving at a constant speed must have unchanged kinetic energy - the correct response. 18% considered that momentum would be constant (distractor C), showing a failure to appreciate that momentum is a vector, whilst 17% considered that the force is in the same direction as the particle's displacement (distractor A).

6 This question involved deciding when a particle oscillating in simple harmonic motion experiences its greatest negative acceleration. Almost four-fifths of the candidates chose the correct answer, at maximum positive displacement. The most common distractor was D, representing maximum negative velocity, which was chosen by 11%.

7 The outwardly more demanding this question, which had appeared in a previous PA04 test, was also on shm. It required an algebraic expression for the magnitude of the acceleration of a body when at maximum displacement. This time 75% of the candidates gave the correct response, but perhaps it was the same 11% of them that were tempted by distractor A (zero acceleration). This was the most discriminating question on the paper.

8 This question required the angular velocity of the Earth's surface. This proved to be one of the easiest questions, with a facility of 79%. The remaining candidates split their responses almost equally between distractors A, C and D. The question gave good discrimination.

9 In this question, two-thirds of the candidates understood that kinetic energy is the quantity having its minimum value at the lowest position of the oscillating mass. Almost one-fifth of them selected the potential energy of the system, no doubt because they had overlooked the elastic potential energy of the spring. This question was not a particularly strong discriminator.

10 This question was concerned with the $T^2 \propto l$ relationship for a simple pendulum. 61% of the candidates recognised that a doubling of T implies that l has been quadrupled. Distractors B and C each attracted about one-sixth of the responses. The question showed the greatest improvement over the pre-test facility of any of the questions in this paper and it was a good discriminator.

11 This question raised similar demands to the previous question, in that they required more than one concept to be combined to give an algebraic result. In this question, the topics were circular motion and kinetic energy. Candidates were more successful here, producing a facility of 62% and good discrimination. Confusion between T and T^2 caused 19% of them to select discriminator C.

12 This question required rather more insight than some questions on circular motion that have been used in the recent past. With a facility of 41%, this was the most demanding question on the paper. 27% of the candidates, who did not fully realise what happens when the string breaks, chose distractor A (a straight line) for the subsequent path. It is less easy to explain why 30% of the candidates chose distractor C, for this suggests that almost one in three of them could not distinguish between horizontal and vertical planes.

13 This question was concerned with the damping force in a vibrating system. The 2005 candidates evidently had a better understanding of this topic than those who answered this question on an Advanced paper five years earlier, because the facility advanced from 57% then to 62% this time. Although there was no particularly strong distractor, the question did not discriminate very well.

15 This question, on simple harmonic motion, required candidates to substitute the given values in the equation $v^2 = (2\pi f)^2(A^2 - x^2)$, as well as to appreciate that $f = 1/T$. This caused fewer problems than expected, because the facility rose to 80% from a facility of 69% when it was last used in a linear A level examination.

16 This question was concerned with resonance and damping. 69% of the candidates arrived at the correct response, a slight improvement on the pre-test result. The question had the lowest discrimination index (0.36) of any of the questions on this paper, possibly because it was one of three questions in this test that required candidates to identify an *incorrect* statement.

17 This question, which tested angular speed, showed a facility from 55% to 78%. It was also one of the best discriminators in this test.

18 This question tested the graphical relationship between kinetic energy and displacement in simple harmonic motion. The facility of 59% was an improvement over the 50% achieved when this question was pre-tested. Almost one in five of the candidates chose distractor A, forgetting that there are two cycles of energy for every cycle of displacement.

19 This question was set in the context of a simple pendulum experiment, requiring candidates to show knowledge of how *g* could be found from the gradient of a graph of T2 against l. The facility was 69%. Distractor B, chosen by one in six, was the most popular incorrect response; this may suggest that these candidates had difficulty with algebraic re-arrangement.

20 This question amounted to a two-stage calculation on simple harmonic motion. The facility of 84% was a significant advance on that of 67% in the pre-examination test. Wrong responses were almost equally divided between distractors A, B and D.

21 This question, also on circular motion, involved a calculation. Candidates were rather less successful with this question and the facility was 65%. However, the same question had been used in the 1995 A level examination, when the facility was only 59%. Almost a quarter of the 2004 candidates chose distractor C.

22 This question was also found to be easy (facility 84%), although a lower discrimination index than the first six questions points to the fact that even the best candidates do not always fully understand what is happening in circular motion.

23 This question tested candidates' understanding of the acceleration of a particle moving with simple harmonic motion. Over half of the candidates gave the correct response, but one in five of them thought that the acceleration was greatest at zero displacement.

24 This question involved a calculation of the maximum kinetic energy of a particle moving in SHM. The examination facility of this question was 57%, much better than the pre-examination facility of 38%. Incorrect responses were fairly evenly split between the three remaining distractors.

25 This question was one of the more demanding questions in this paper. No doubt the algebra required to think through what happens when the length of a pendulum is changed was the main obstacle to the progress of weaker candidates. The examination facility was 47%.

However the question was one of the best discriminators in this paper, with a discrimination index of 0.52. 41% of the candidates chose distractor C, suggesting either that they did not understand that $T \propto l^{1/2}$, or that they were guessing that half the length would give half the period.

26 Understanding of the forces involved in circular motion was a prerequisite for this question. Although the examination facility of this question was 62%, the discrimination index (0.30) was the poorest of any question on this paper (however this is better than when the question was last used in an old AS paper). For teaching purposes it is important to note that nearly 20% of the candidates considered that the force keeping the mass at rest relative to the disc is a frictional force directed along a tangent to the circular path.

27 Most candidates were able to deal competently with this question, where almost four-fifths of them obtained the correct value for the angular speed of the roundabout.

28 This question was concerned with the phase difference between velocity and displacement in simple harmonic motion. The facility of 59% corresponded exactly with that in the preexamination test. Candidates who chose wrong answers were almost equally divided between distractors A and D, suggesting that there is much confusion in understanding whether 90° means ð/2, ð/4, or 2ð radians.

29 This question tested knowledge of acceleration in SHM and was answered correctly by almost two-thirds of the candidates, which compares favourably with two-fifths in a previous AS examination.

30 This question involved calculating the displacement of a model car moving in a circle. Just over half of the candidates chose the correct response, more or less in line with the previous facility of 57% for this old A level question.