A-level Physics (7407/7408)

Name:

Class:

Further Mechanics Test

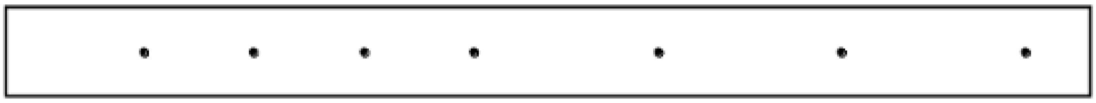
Date: **September 2016**

Time: **55**

Marks: **47**

Q1. The diagram shows a strobe photograph of a mark on a trolley **X**, moving from right to left, in collision with another trolley **Y** which had no mark on it.

After the collision both trolleys are in motion together.



Which **one** of the following is consistent with the photograph?

A Trolley **Y** has the same mass as trolley **X** and was initially stationary

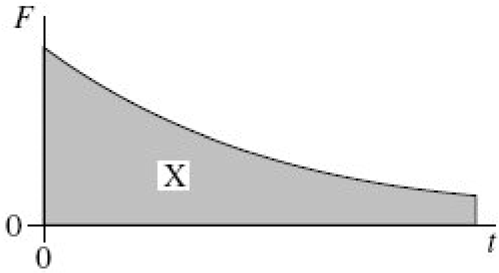
B Trolley **Y** had a smaller mass than **X** and was moving from right to left

C Trolley **Y** had the same mass and was initially moving left to right at the same speed as trolley **X**

D Trolley **Y** had the same mass and was initially moving left to right at a higher speed than trolley **X**

(Total 1 mark)

Q2. The graph shows the variation with time, *t*, of the force, *F*, acting on a body.



What physical quantity does the area X represent?

A the displacement of the body

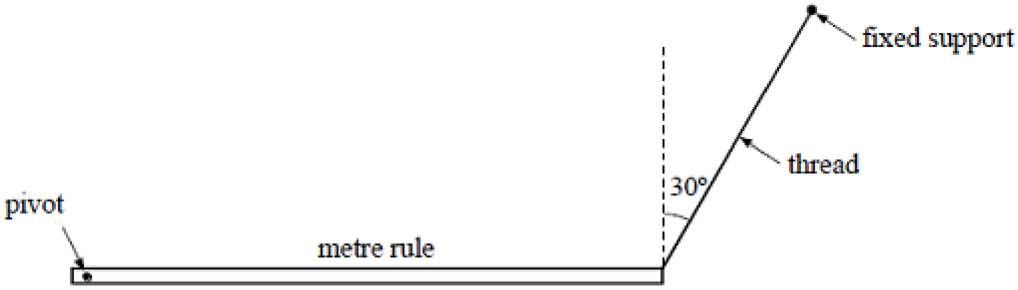
B the acceleration of the body

C the change in momentum of the body

D the change in kinetic energy of the body

(Total 1 mark)

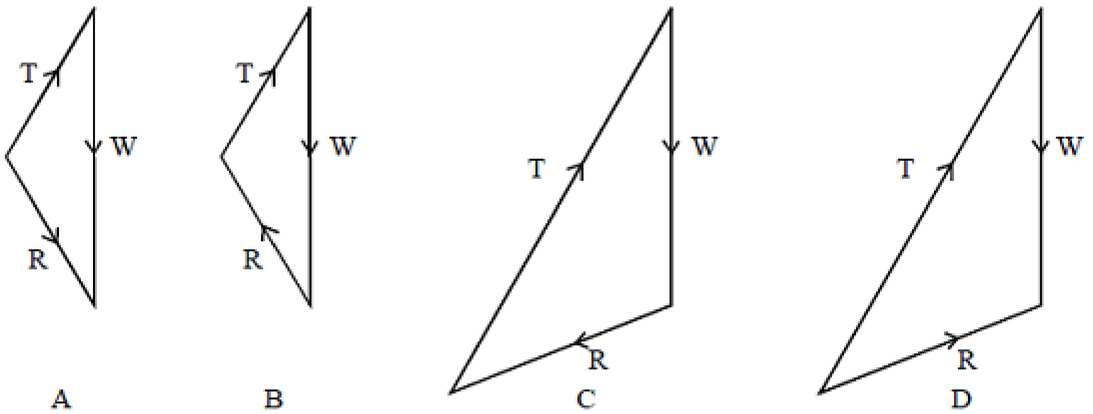
Q3. A pivoted metre rule is supported in equilibrium horizontally by a thread inclined at 30° to the vertical.



The three forces acting on the rule are:

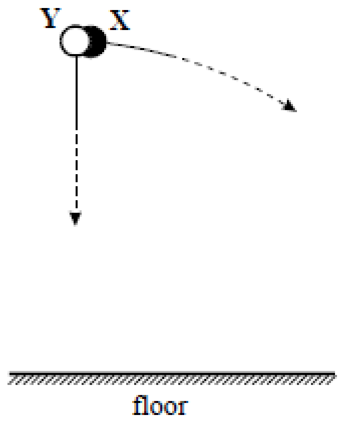
its weight W;
the tension T in the thread;
the reaction force R at the pivot.

Which one of these diagrams, drawn to scale, represents the magnitudes and directions of these three forces?



(Total 1 mark)

Q4. A ball **X** is projected horizontally from a certain point at the same time as a ball **Y** of the same diameter but twice the mass is released from rest and allowed to fall vertically from the same level. Air resistance is negligible. Which one of the following will occur?



A **Y** will hit the floor just before **X**

B **X** will hit the floor just before **Y**

C **X** and **Y** will hit the floor at the same time

D **Y** hits the floor while **X** is half way to the floor

(Total 1 mark)

Q5. Which line, **A** to **D**, in the table shows correctly whether the moment of a force, and momentum, are scalar or vector quantities?

	moment of force	**momentum**
A	scalar	scalar
B	scalar	vector
C	vector	scalar
D	vector	vector

(Total 1 mark)

Q6. 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 same direction as the displacement.

C It is in the opposite direction to the velocity.

D It is proportional to the displacement.

(Total 1 mark)

Q7. An object falls freely from rest. After falling a distance d its velocity is v. What is its velocity after it has fallen a distance $2d$?

A $2v$ ☐

B $4v$ ☐

C $2v^2$ ☐

D $\sqrt{2}\,v$ ☐

(Total 1 mark)

Q8. An electric motor of input power 100 W raises a mass of 10 kg vertically at a steady speed of 0.5 m s^{-1}. What is the efficiency of the system?

A 5% ☐

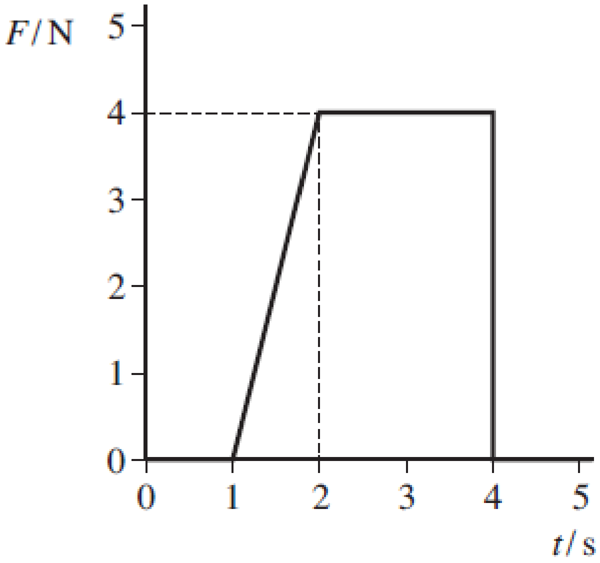
B 12% ☐

C 50% ☐

D 100% ☐

(Total 1 mark)

Q9. The graph shows how the resultant force, *F*, acting on a body varies with time, *t*.



What is the change in momentum of the body over the 5 s period?

A 2N s

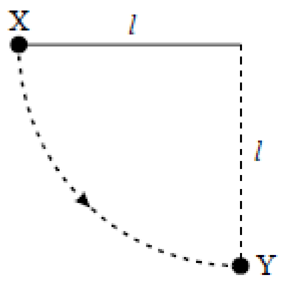
B 8N s

C 10N s

D 12N s

(Total 1 mark)

Q10.



A ball of mass m, which is fixed to the end of a light string of length l, is released from rest at X. It swings in a circular path, passing through the lowest point Y at speed v. If the tension in the string at Y is T, which one of the following equations represents a correct application of Newton's laws of motion to the ball at Y?

A $T = \frac{mv^2}{l} - mg$

B $T - mg = \frac{mv^2}{l}$

C $mg - T = \frac{mv^2}{l}$

D $T + \frac{mv^2}{l} = mg$

(Total 1 mark)

Q11. Which line, **A** to **D**, in the table gives the amplitude and frequency of a body performing simple harmonic motion whose displacement x at time t is given by the equation :

$$x = P \cos Qt$$

	Amplitude	Frequency
A	$\frac{P}{2}$	$\frac{Q}{2\pi}$
B	P	$2\pi Q$
C	P	$\frac{Q}{2\pi}$
D	$2P$	$\frac{Q}{2\pi}$

(Total 1 mark)

Q12. The tip of each prong of a tuning fork emitting a note of 320 Hz vibrates in simple harmonic motion with an amplitude of 0.50 mm.
What is the speed of each tip when its displacement is zero?

A zero

B 0.32π mm s^{-1}

C 160π mm s^{-1}

D 320π mm s^{-1}

(Total 1 mark)

Q13. (a) The equation that describes simple harmonic motion is

$$a = -\omega^2 x.$$

State the meaning of the symbol ω in this equation and go on to explain the significance of the negative sign.

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(2)

(b) **Figure 1a** shows a demonstration used in teaching simple harmonic motion. A sphere rotates in a horizontal plane on a turntable. A lamp produces a shadow of the sphere. This shadow moves with approximate simple harmonic motion on the vertical screen.

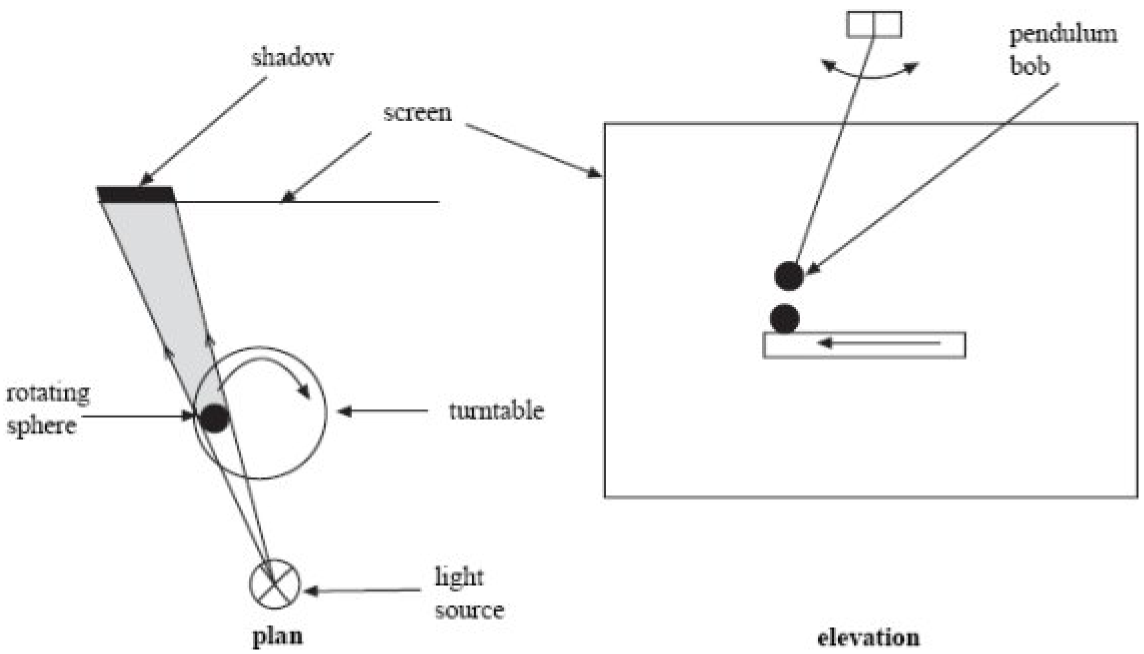

Figure 1a **Figure 1b**

(i) The turntable has a radius of 0.13 m and the teacher wishes the time taken for one cycle of the motion to be 2.2 s. The mass of the sphere is 0.050 kg.

Calculate the magnitude of the horizontal force acting on the sphere.

(2)

(ii) State the direction in which the force acts.

....

(1)

(c) **Figure 1b** shows how the demonstration might be extended. A simple pendulum is mounted above the turntable so that the shadows of the sphere and the pendulum bob can be seen to move in a similar way and with the same period.

(i) Calculate the required length of the pendulum.

acceleration due to gravity = 9.8 m s^{-2}

(1)

(ii) Calculate the maximum acceleration of the pendulum bob when its motion has an amplitude of 0.13 m.

(2)

(d) **Figure 2** includes a graph of displacement against time for the pendulum. Sketch, on the axes below, graphs of

(i) acceleration against time for the bob, and

(ii) kinetic energy against time for the bob.

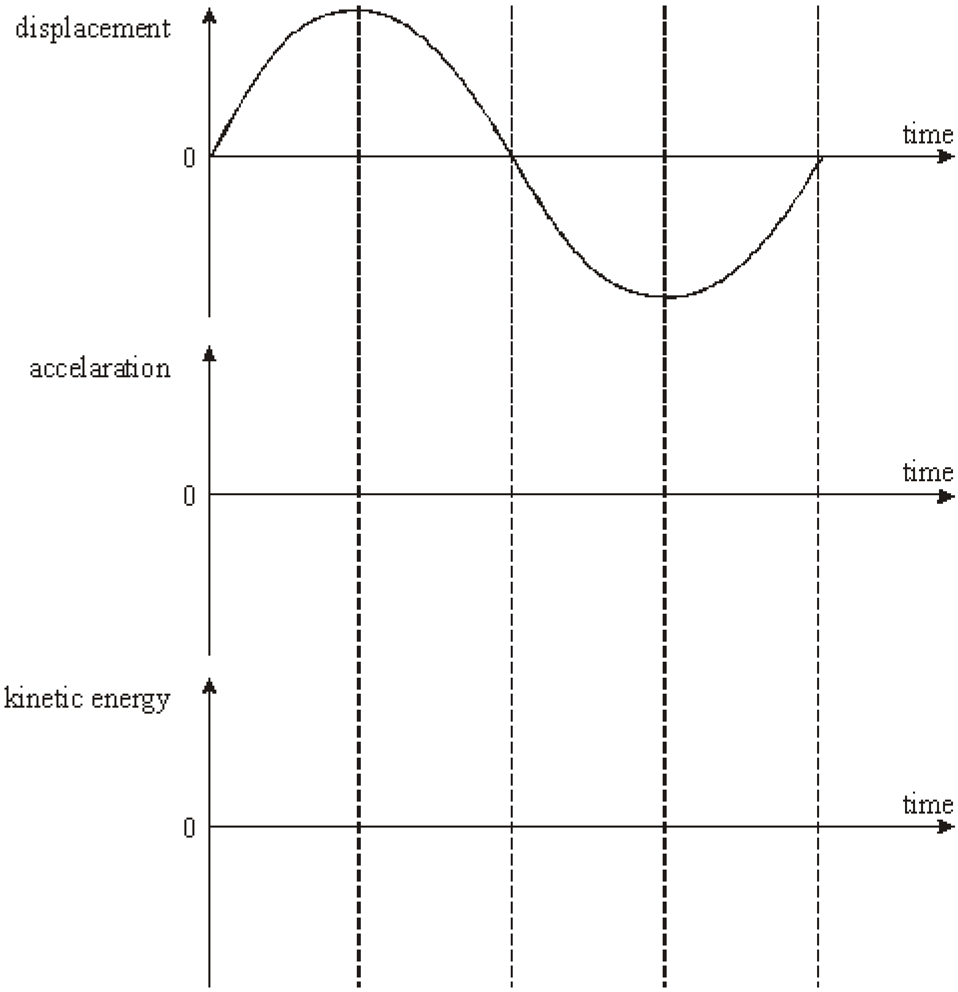

Figure 2

(4)
(Total 12 marks)

Q14.(a) State the conditions necessary for a body to execute simple harmonic motion.

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(2)

(b) The front wheel of a motorcycle is attached to the frame via a combination of springs which has a spring constant of 4.2×10^3 N m^{-1}. You may consider this suspension system to be undamped. **Figure 1** shows the variation of displacement with time for the system when it is caused to oscillate after the wheel passes over a bump in the road.

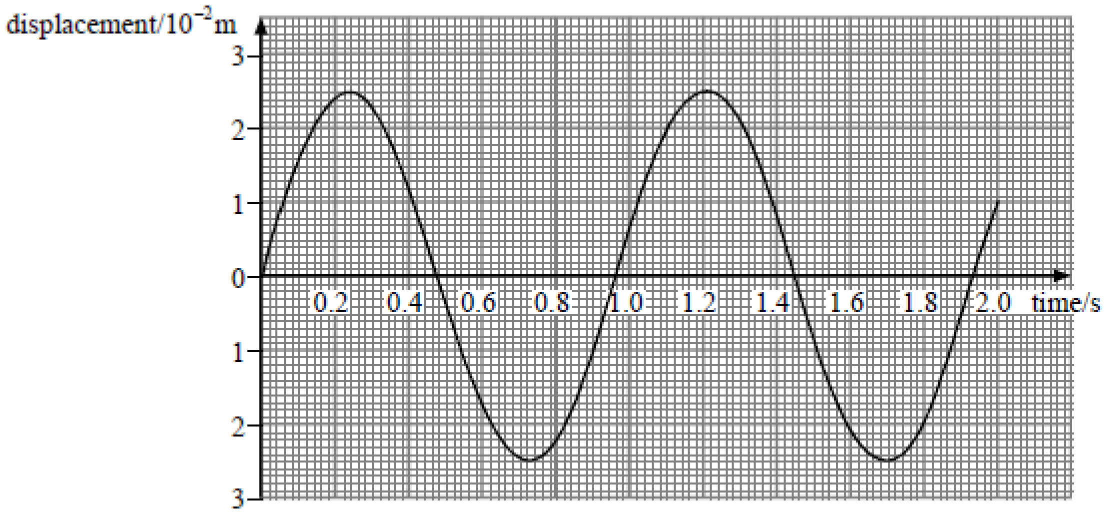

Figure 1

(i) State the periodic time for the oscillation of the system.

....

(1)

(ii) Calculate the frequency of oscillation of the system.

(1)

(iii) Calculate the effective mass which is attached to the suspension system.

(2)

(iv) Calculate the maximum acceleration of the wheel relative to the frame when the system oscillates as shown in **Figure 1**.

(2)

(c) When approaching a roundabout at a speed of 7.0 m s^{-1}, the motorcycle moves over raised road markings separated by a distance of 1.2 m. By making a suitable calculation, decide whether the front wheel system of the motorcycle is likely to experience resonance when it crosses the road markings. Explain your answer.

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(3)

(d) In practice, the system is damped by a shock absorber. **Figure 2** shows the oscillation of the damped system after the wheel goes over a bump in the road.

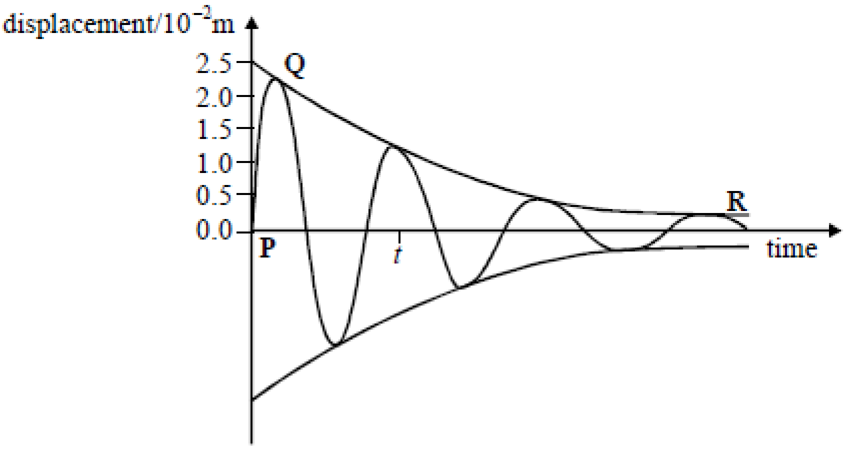

Figure 2

(i) Describe the energy changes that occur during the time covered by **Figure 2**, making reference to the types of energy involved at **P**, **Q** and **R**.

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(3)

(Total 14 marks)

Q15.(a) **Figure 1** and **Figure 2** each show a car travelling in a horizontal circular path.

(i) Draw and label on **Figure 1** and **Figure 2** arrows to indicate the other forces acting on the cars.

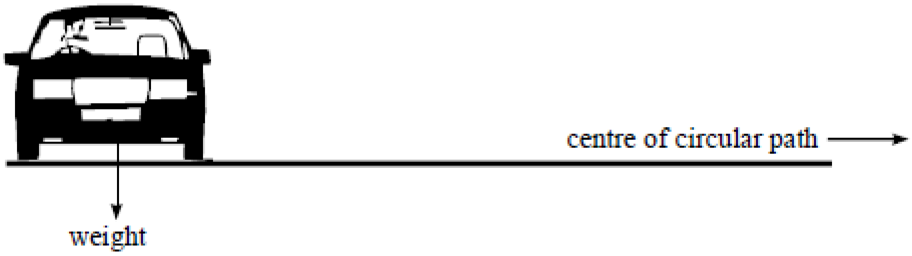

Figure 1

Figure 2

(2)

(ii) State the possible origins of the centripetal force on the car in **Figure 2**.

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....

....

(4)

(b) **Figure 3** shows a motorcycle stunt rider travelling around a track in a vertical circle of radius 5.2 m. At position **Q**, when the speed is the minimum necessary to keep the motorcycle in contact with the track, the centripetal force is supplied by the weight of the motorcycle and rider. The combined mass of the motorcycle and rider is 220 kg.

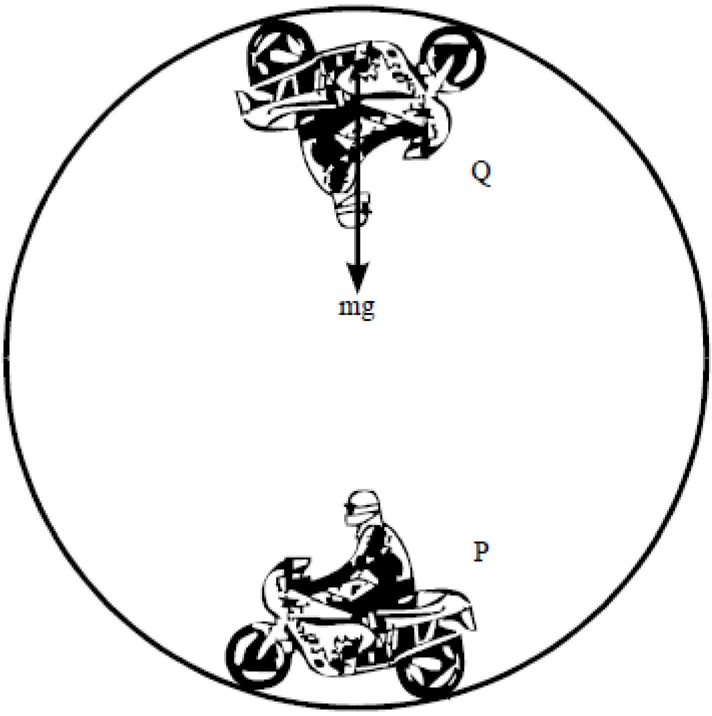

Figure 3

Calculate the minimum speed which will keep the motorcycle in contact with the track at position **Q**. The acceleration due to gravity, g, is 9.8 m s^{-2}.

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....

....

(3)
(Total 9 marks)

M1. A

[1]

M2. C

[1]

M3. B

[1]

M4. C

[1]

M5. D

[1]

M6. C

[1]

M7. D

[1]

M8. C

[1]

M9. C

[1]

M10. B

[1]

M11. C

[1]

M12. D

[1]

M13. (a) $2\pi/T$ or $2\pi f$ **or** angular speed/velocity/frequency/$\Delta\theta \div \Delta t$ *with symbols defined*

B1

displacement direction opposite to acceleration vector/ acceleration towards central point/equilibrium point

B1

2

(b) (i) $\omega = 2\pi/T = 2.86$ rad/s *can appear as* ($2\pi/2.2$) in

C1

subst
F = 0.053(1) N

A1

2

(ii) to centre of turntable/rotation/circle *not* 'towards centre'

B1

1

(c) (i) $l = [T^2g/4\pi^2] = 1.20$ m

A1

1

(ii) correct use of $a = \omega^2A$

M1

or accel = v^2/r or F/m approach
a = 1.0 / 1.1 / 1.04 / 1.06 m s^{-2} [cao]

A1

2

(d) *a* origin at zero

C1

a in antiphase

A1

k.e always positive and start at maximum

C1

k.e. twice *f* and good shape

A1

4

[12]

M14.(a) force / acceleration proportional to displacement / distance from mean position **B1**

directed towards mean / fixed position **B1**

(2)

(b) (i) 0.96 s to 0.98 s **B1**

(1)

(ii) 1.02 Hz to 1.04 Hz e.c.f. 1 / (i) **B1**

(1)

(iii) $T = 2\pi\sqrt{m / k}$ **or** $m = T^2k / 4\pi^2$ in symbols or numbers, seen or used **C1**

98 kg to 102 kg e.c.f. $10^6 \times$ (i)^2 **A1**

(2)

(iv) $a = (-)\omega^2 A$ **C1**

1.03 m s^{-2} to 1.07 m s^{-2} e.c.f. 0.99(ii)^2 **A1**

(2)

c) time period (of oscillation caused by road markings) = s / v or 1.2 / 7 or 0.17 s **C1**

frequency = 1 / T or 5.8 Hz
(use of $v = f\lambda$ loses both of the 1st two marks) **A1**

applied frequency / time period is different from natural / resonant frequency so no resonance **B1**

(3)
6

(d) (i) KE at **P**

B1

PE at **Q**

B1

at **R**, (nearly all of) energy absorbed by shock absorber / dissipated as internal energy (condone heat) in shock absorber / surroundings (allow lost in damping)

B1

(3)

[14]

M15.(a) (i) a normal reaction shown and labelled on either diagram

B1

a frictional force correctly shown and labelled on either diagram (may be outward on second diagram)

deduct 1 mark for each wrong force (condone poor friction / reaction)

B1

(2)

(ii) friction (between surface and wheel / tyre)

B1

(normal) reaction (at the surface)

B1

horizontal component of either force / component towards the centre

B1

sum of horizontal components

B1

(4)

(b) use of $mg = mv^2 / r$ or $g = v^2r$, centripetal force = mv^2 / r

C1

correct substitution $v^2 = 9.8 \times 5.2$

C1

7.1 m s^{-1}

A1

(3)

[9]