Advanced Higher Physics

Mechanics

Past Paper Questions

Solutions

1. (a) (i) use $s = ut + {}^1/_2at^2$

(ii) 1.18 ms^{-2}

(iii) 0.06 s

(iv) %unc in s = 0.28%

% unc. in t = 2.44%; % unc in t^2 = 4.9%

% unc in a = 4.9%

(v) (1.18 ± 0.06) ms^{-2}

(b) (i) 9.0 ms^{-2}

(ii) centripetal force = ma = 2.5 x 9.0 = 23.5 N so

friction of 23 N is ***insufficient*** (question is incorrect)

(c) there is a component of the normal reaction of the track on the car acting towards the centre of the circular path which provides at least some of the required centripetal force

2. (a) (i) 3.13 ms^{-2}

(ii) unc in distance = 1%
unc in time = 5%; unc in time squared = 10%

unc in accel = 10%

(b) $\alpha = {}^a/_r$ 10.4 $rads^{-2}$

(c) (i) at a certain maximum speed, the angular acceleration is so large that the centripetal force needed to keep the stone moving in a circle is greater than the friction between the stone and the tread (3.0 N)

(ii) 15 3 ms^{-1}

(iii) horizontally forward in direction of motion of car

3. (a) see notes

(b) 1.29×10^{-13} J

4. (a) use $\frac{GM_E m}{r^2} = \frac{mv^2}{r}$

and $\omega = \frac{2\pi}{T}$

(b) (i) 3.6×10^{7} m

(ii) 3050 ms^{-1}

(c) (i) velocity of projection which would allow body to reach 'infinity' where gravitational potential energy is zero

(ii) 10,900 ms^{-1} or 11 kms^{-1}

5. (a) 2.83×10^{8} ms^{-1}

(b) 1.88×10^{-13} J

6. (a) see notes

(b) 4.2×10^{-10} J

7. (a) (i) force acting on a unit mass due to a planet's gravitational field

(ii) (A) use $F = \frac{GMm}{r^2}$ and $F = mg$

(B) 6.4×10^{23} kg

(b) (i) 312 N

(ii) 6890 s

8. (a) see notes

(b) (i) (A) -4.30×10^{7} J

(B) -3.32×10^{7} J

(ii) 9.8×10^{6} J

(iii) 1140 ms^{-1}

9. (a) (i) 1.98×10^{20} N

(ii) 1020 ms^{-1}

(iii) work done per unit mass in bringing the mass from infinity to the point in space

(iv) -7.6×10^{28} J

(v) easiest to divide by '2' and make +ve: 3.8×10^{28} J

(b) (i) $v_E = \sqrt{GM/R}$

(ii) 1700 ms^{-1}

10. (a)

(b) (i) use equation in (a) but remember to have radius of orbit as radiius of Earth plus height of orbit (6.48×10^{6}m)

(ii) $s = \theta r = \omega Tr = 2400$ km

11. (a) use $g = GM/R^2$

(b) (i) use $m\omega^2 R = GMm/R^2$

(ii) use equation in (b)(i) but ensure R = Mars' radius + satellite height (2.04×10^{7})

$\omega = 7.1 \times 10^{-5}$ rads $^{-1}$

(iii) 24.6 hours

(c) divide T^2 by R^3 for each pair of values and show that it is a constant (3.0×10^{-7}) *or* draw a graph of T^2 by R^3 and show it's a straight line through the origin

12. (a) (i)

(ii) 2.38×10^{6} s = 661 hours = 27.5 days

(b) (i) use $E = -\frac{GMm}{r}$ where r = 6.8×10^{6} m (Earth radius + height)

(ii) easiest to smiply divide (i) answer by 2 = -2.65×10^{10} J

13. (a) (i) 6.75×10^{-3} kgm^2

(ii) (A) change revs to rad by multiplying by 2π and divide by 60

(B) 3.1 rads^{-2}

(iii) conservation of angular momentum (L = Iω)

I for mass = 2.0×10^{-3} kgm^2

3.6 rads^{-1}

(iv) insufficient friction between surface of turntable and mass to provide cetripetal force needed to keep mass moving in a circle (force larger at bigger radius)

(b) increases; angular momentum (Iω) of skater conserved - by pulling in limbs, moment of inertia (I) decreases so angular velocity (ω) needs to increase to keep Iω constant

Note: there is no Q 14!

15. (a) (i) 300 rads^{-2}

(ii) 0.153 Nm

(iii) 382 revolutions

(b) (i) use $F = m\omega^2 r$ = 0.65 N

(ii) normal reaction of the test tube

22. (a) use rads = revs x 2π ω = 62.8 rads^{-1}

(b) $\alpha = 2.1$ rads $^{-2}$

(c) 150 revs

(d) use $\tau = I\alpha$; $\tau = 4.5 \times 10^{-3}$ Nm

(e) time will be greater (almost 3 times) as moment of inertia of disc is larger (8 times) due to larger mass and distribution of mass closer to axis of rotation

23. (a) motion of object where the force acting on it is proportional to the distance from the centre of the motion and is always directed towards the centre

(b) $y = 0.050 \sin 200\pi t$ or $y = 0.050 \cos 200\pi t$

(c) occurs at extremities and is $\pm A\omega^2$ where $\omega = 2\pi f$

$a = 20000$ ms $^{-2}$

(d) use $F = ma$ $F = 9600$ N

(e) maximum velocity at centre is $\pm A\omega$

use $E = {}^1/_2 mv^2$ $E = 240$ J

24. (a) (i) potential energy and both roatational and translational kinetic energy

(ii) rotation kinetic energy

(b) $I = 2.5 \times 10^{-4}$ kgm ^{2}

(c) use $E = {}^1/_2 I\omega^2$ and equate to $E = mgh$ $h = 0.92$ m

(d) (i) larger cetripetal force needed to keep pads moving in a circle at higher angular speed and this is supplied by the tension in the spring; to increase tension, spring needs to be compressed, hence pads move outwards

(ii) use $m\omega^2 r = F_c = 5.00$ $\omega = 204$ rads $^{-1}$