Parent's Signature …………………..

Candidate's Name ………………………………………………. CTG ……………

YISHUN JUNIOR COLLEGE
2015 JC 1 BLOCK TEST

PHYSICS **9646/2**

HIGHER 2 **11 June 2015**

Thursday

Paper 2 **1 hour 30 minutes**

INSTRUCTIONS TO CANDIDATES

Do not open this booklet until you are told to do so.

Write your name and CTG in the spaces provided above.

Write in dark blue or black pen on both sides of the paper.

Do not use paper clips, highlighters, glue or correction fluid.

The use of approved scientific calculator is expected, where appropriate.

Answer **all** questions.

All working must be shown clearly in the spaces provided.

Paper 1	
	/20
Paper 2	
Q1	**/5**
Q2	**/13**
Q3	**/16**
Q4	**/16**
Q5	**/10**
Penalty	
Total	
	/60
Final Total	
	/80
	%

This question paper consists of **16** printed pages.

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	=	8.85×10^{-12} F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
Acceleration of free fall	g	=	9.81 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	=	$\rho g h$
gravitational potential,	ϕ	=	$-\dfrac{Gm}{r}$
Displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_o \cos \omega t$
		=	$\pm \omega \sqrt{(x_o^2 - x^2)}$
resistors in series,	R	=	$R_1 + R_2 + \ldots\ldots\ldots\ldots$
resistors in parallel,	$\dfrac{1}{R}$	=	$\dfrac{1}{R_1} + \dfrac{1}{R_2} + \ldots\ldots$
electric potential,	V	=	$\dfrac{Q}{4\pi\varepsilon_o r}$
alternating current/voltage,	x	=	$x_o \sin \omega t$
transmission coefficient	T	=	$\exp(-2kd)$, where $k = \sqrt{\dfrac{8\pi^2 m(U-E)}{h^2}}$
radioactive decay,	x	=	$x_o \exp(-\lambda t)$
decay constant,	λ	=	$\dfrac{0.693}{t_{\frac{1}{2}}}$

Answer all questions. Show your workings clearly in the spaces provided.

1 (a) If $X = 2C - D$ where $C = (2.3 \pm 0.3)$ and $D = (1.8 \pm 0.1)$, determine X with its associated uncertainty.

$\Delta X = 2\Delta C + \Delta D$
$= 2(0.3) + (0.1)$
$= 0.7$ (1 s.f)

$X = 2C - D = 2(2.3) - (1.8) = 2.8$

$X \pm \Delta X = 2.8 \pm 0.7$

$X \pm \Delta X$ = ………… ± ………… [2]

(b) If $A = \dfrac{\sqrt{B^3}}{2C - D}$ where $B = (1.3 \pm 0.1)$, hence from part (**a**) or otherwise, determine A with its associated uncertainty.

$$A = \frac{B^{3/2}}{X} = \frac{(1.3)^{3/2}}{2.8} = 0.529$$

$$\frac{\Delta A}{A} = \frac{3}{2}\frac{\Delta B}{B} + \frac{\Delta X}{X}$$

$$\Delta A = \left(\frac{3}{2}\frac{\Delta B}{B} + \frac{\Delta X}{X}\right)A$$

$$= [(\frac{3}{2})(\frac{0.1}{1.3}) + \frac{0.7}{2.8})][0.529]$$

$= 0.193$
≈ 0.2 (1 s.f)

$A \pm \Delta A = (0.5 \pm 0.2)$

$A \pm \Delta A$ = …….……. ± ………… [3]

2 **(a)** A car is travelling at 8.0 m s^{-1} passes by a stationary train at time, t = 0. The variations with time of the velocity v of the train and car are shown in Fig. 2.1.

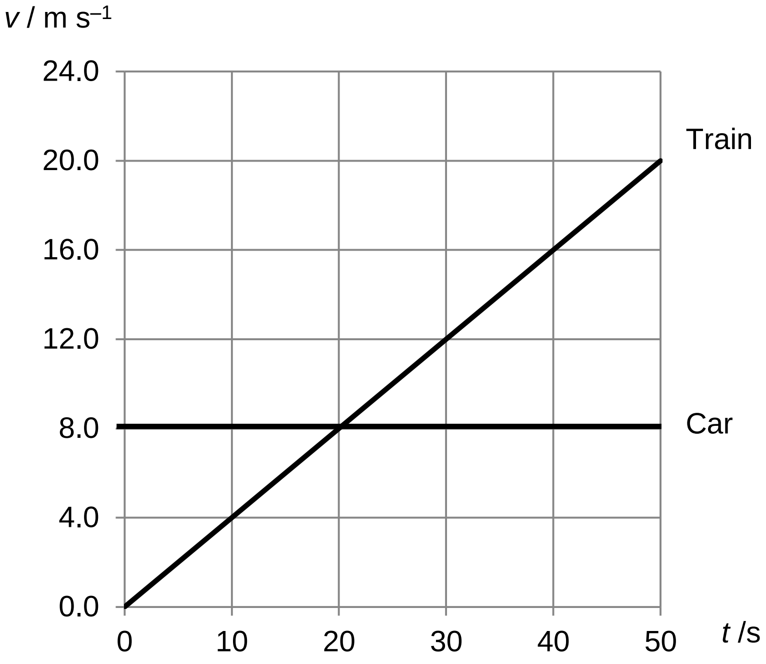


Fig. 2.1

(i) Calculate the acceleration of the train.

$v = u + a t$
$20 = 0 + a (50)$
$a = 0.40$ m s^{-2}

acceleration = ………………………… m s^{-2}

[1]

(ii) Calculate the distance travelled by the train when it passes by the car again.

$s_{car} = 8\,t$
$s_{train} = u\,t + ½\,a\,t^2$
$= ½ (0.40)\,t^2$
For the train and car to pass by each other, $s_{car} = s_{train}$.
$8\,t = ½ (0.40)\,t^2$
$t = 40$ s
$s_{train} = s_{car}$
$= 8 (40) = 320$ m

distance = ………………….. m [3]

2 **(b)** A ball is projected at an angle of 30° above the ground with a speed of 40 m s^{-1} as shown in Fig. 2.2. A vertical wall of infinite height is placed 120 m away from the point where the ball is launched.

Fig. 2.2

(i) Calculate the time taken for the ball to reach the highest point of its path.

$v_y = u_y + at$

$0 = 40 \sin 30 - 9.81t$

$t = 2.04$ s

time taken = ……………………………….. s [1]

(ii) Calculate the time taken for the ball to hit the wall.

$s_x = u_x t$ $\rightarrow$ +ve

$120 = (40 \cos 30^o)\ t$

$t = 3.46$ s

time taken = ……………………………….. s [1]

(iii) Calculate the height of the ball above the ground when it hits the wall.

$s_y = u_y t + \frac{1}{2} a_y t^2$ $\uparrow$ +ve

$= (40 \sin 30^o)(3.46) + \frac{1}{2}(-9.81)(3.46^2)$

$= 10.5$ m

height of the ball = ……………………………… m [2]

(iv) Calculate the vertical component of the velocity when the ball hits the wall.

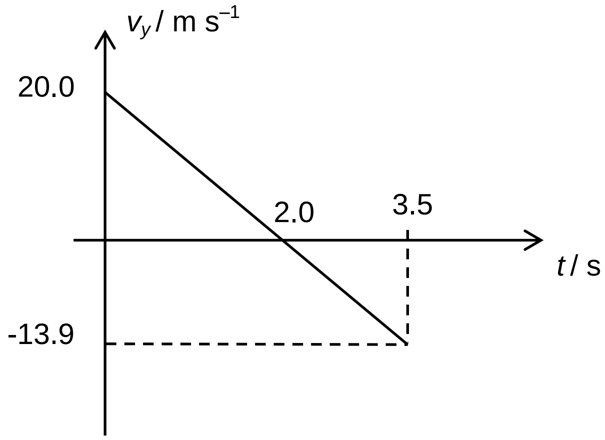
$v_y = u_y + a_y t$

$= 40 \sin 30^o + (-9.81)(3.46)$

$= -13.9 \text{ m s}^{-1}$

magnitude of the vertical velocity = …………………….. m s^{-1} [1]

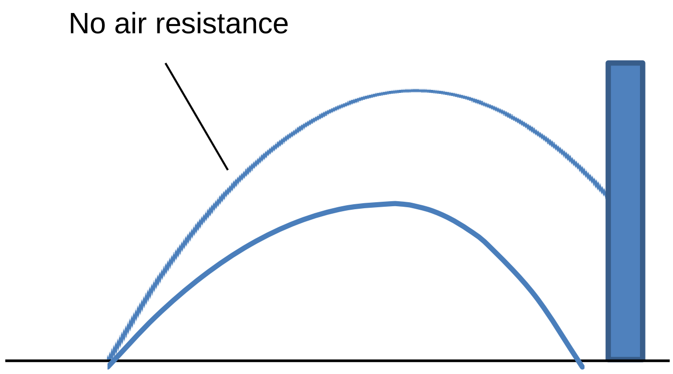
(v) On Fig. 2.3, sketch the variation with time of the vertical component of the velocity, v_y, taking upwards as positive. Indicate the critical values on the graph, where applicable. [2]



Note: the area under the graph after the highest point is smaller than the area under the graph before the highest point.

(vi) Assuming that the effect of air resistance is not negligible, draw the projectile path of the ball in Fig. 2.4. The projectile path of the ball with no air resistance is shown in Fig. 2.4. [2]

Note: path drawn should have lower peak and lower trajectory, the peak of the path with air resistance should be nearer the initial point, the path should be asymmetrical and the range should be shorter.



3 **(a)** Define linear momentum of a body.

Linear momentum of a body is the product of its mass and velocity.
....

.... [1]

(b) Two frictionless trolleys A and B are moving horizontally in the same direction on a frictionless surface, as shown in Fig. 3.1.

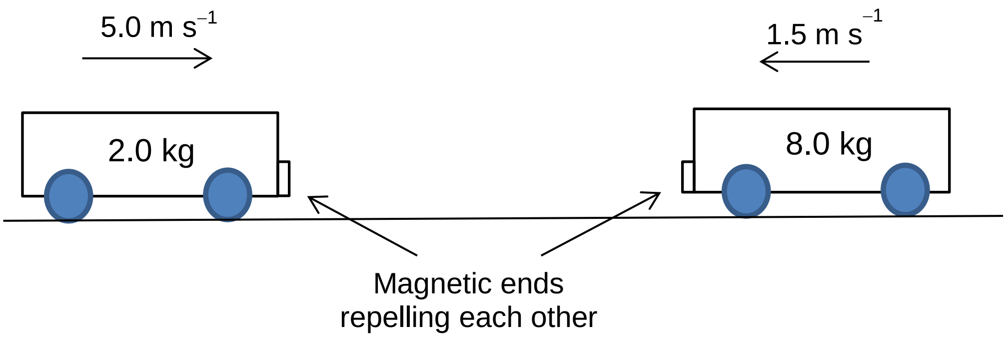


Fig. 3.1

Trolley A of mass 2.0 kg has a speed of 5.0 m s^{-1} and trolley B of mass 8.0 kg has a speed of 1.5 m s^{-1}. The trolleys collide elastically.

(i) Calculate the momentum of the 2.0 kg trolley before the collision.

$P_{2.0} = m\,v = 2.0\ (5.0) = 10$ kg m s^{-1}

momentum = ………………….. kg m s^{-1} [1]

(ii) Determine the velocity of the 2.0 kg trolley after collision.

By conservation of momentum, $\longrightarrow$ +ve

Total P_i = Total P_f

$2.0\,(5.0) + 8.0\,(-1.5) = 2.0(v_1) + 8.0(v_2)$

$-2.0 = 2.0(v_1) + 8.0(v_2)$ ------- (1)

$u_1 - u_2 = v_2 - v_1$

$5.0 - (-1.5) = v_2 - v_1$ -------- (2)

Solving,

$v_1 = -5.4$ m s^{-1}

To the left

speed = ………………….. m s^{-1} [3]

direction = ……………………….. [1]

Note: The two carts do not share the same v after collision since it is not a perfectly inelastic collision.

(iii) Explain whether, during the collision, it is possible for both trolleys to be at rest simultaneously.

Not possible.

Total momentum of the system is always conserved as there is no net external force acting on the system during the collision OR Total momentum of a closed system is always conserved.

Total initial momentum of the system before collision is not zero. [2]

Marker's comments: Many students mentioned that the total kinetic energy cannot be zero since it is an elastic collision, i.e. kinetic energy is conserved. However, they failed to see while it is true that kinetic energy before and after the collision is the same, the kinetic energy during the collision may be converted to potential energy (students should have seen this from the simulation in the practical worksheet) and the total kinetic energy may hence not be equal to the total kinetic energy before collision.

(c) A wooden block P, placed on a horizontal surface, is connected to block Q with an inelastic string over a frictionless pulley as shown in Fig. 3.2.

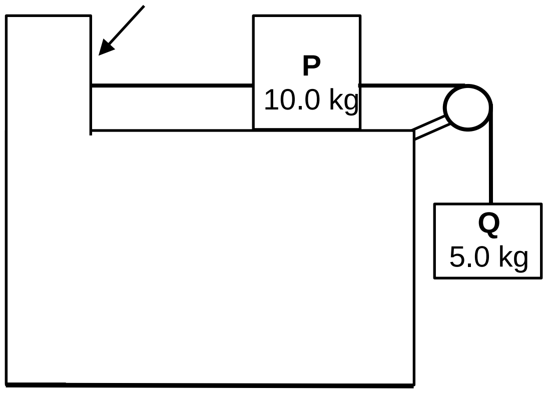


Fig. 3.2

(i) The system is held in equilibrium by another inelastic string attached to a wall. There is a static frictional force of 8.0 N present between block P and the horizontal surface.

1. State and explain the value of the tension in the string between P and Q.

$T = 5.0 \times 9.81 = 49$N

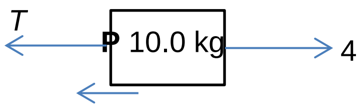
Since the system is in equilibrium, there is no resultant force acting on Q.

The tension acting on Q must equal to the weight of Q

[2]

Marker's comments: Majority of the students managed to give the correct value of the tension. Students have to note the significant figures to be given for their answers although they are not penalised in this question. Many students stopped at stating that the system is in equilibrium and did not mention specifically that $\Sigma F=0$. Some students have mistakenly thought that the weight of Q and the tension forms an action and reaction pair and then explained using Newton's third law.

2. Determine the tension in the string connecting block P to the wall.



$\Sigma F = ma$ 8.0 N

$49 - T - 8.0 = 10.0\ (0)$

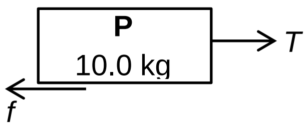
$T = 41$ N

tension = ………………… N

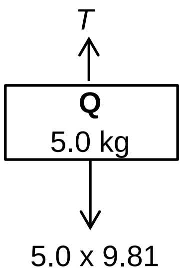
[2]

(ii) The string connecting block P to the wall is now cut and the system accelerates. The frictional force between block P and the surface is reduced to a constant value of 5.0 N. Determine

1. the acceleration of the system



ΣF = ma
$T - 5.0 = 10.0$ a

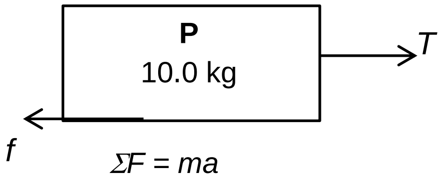


ΣF = ma
$5.0\ (9.81) - T = 5.0$ a

Combining both equations
$5.0\ (9.81) - 5.0 = 15.0$ a
a = 2.9 m s^{-2}

acceleration = ……………………….. m s^{-2} [3]

2. the tension in the string between P and Q.



$\Sigma F = ma$
$T - 5.0 = 10.0$ a
$T = 10.0\ (2.93) + 5.0$
= 34 N

tension = ………………………….. N [1]

4 **(a)** Define the *moment of a force*.

The product of the force and perpendicular distance

from its line of action to the pivot point.

[2]

Marker comments: "Line of action of force" Is a crucial phrase to gain credit but many students fail to include. "Force <u>times</u> perpendicular distance….." is not an appropriate statement.

(b) A force *F* of 160 N is applied horizontally at the axle so that the metal wheel is <u>just lifted off the ground</u> as shown in Fig. 4.1. The radius of the wheel is 0.500 m.

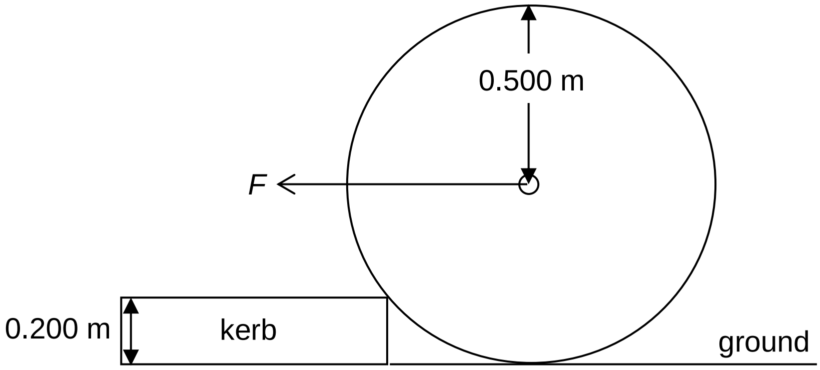


Fig. 4.1

(i) On Fig. 4.1, draw and name the two other forces acting on the wheel. [2]

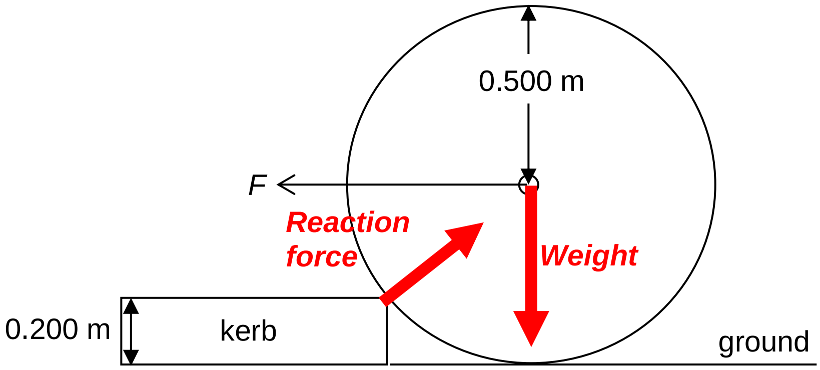


Fig. 4.1

(ii) Calculate the weight of the wheel.

$160\ (0.300) = W\ (0.400) \Rightarrow W = 120$ N

weight of the wheel = ………………….. N [3]

(iii) Let F_{min} be the minimum force applied <u>at the axle</u> that could lift the wheel.

1. On Fig. 4.1, draw F_{min}. [1]

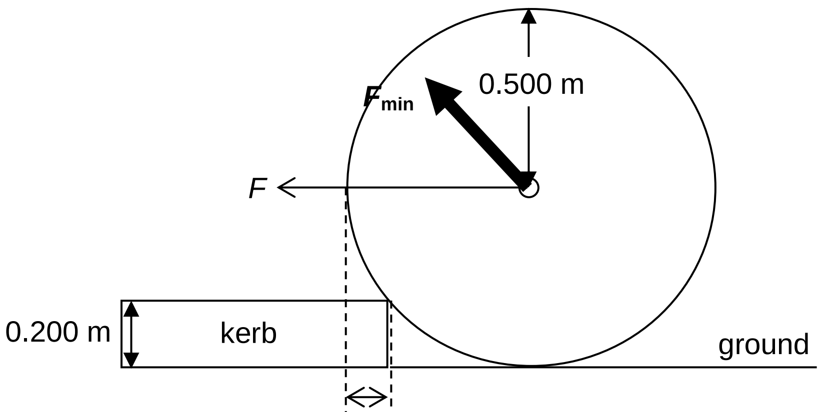


Fig. 4.1

2. Explain why F_{min} needs to be applied in the direction as stated by your answer.

The perpendicular distance between F_{min} and the pivot will be the longest when it is applied .

Hence force applied will be the smallest given the clockwise moments remains the same about the kerb. [2]

(c) **(i)** State Hooke's law.

Hooke's law states that stress is proportional to strain, provided that the elastic limit is not exceeded.

<u>OR</u> force is proportional to extension provided that the elastic limit has not been exceeded [1]

(ii) Fig. 4.2 shows the force-extension graph of a helical spring.

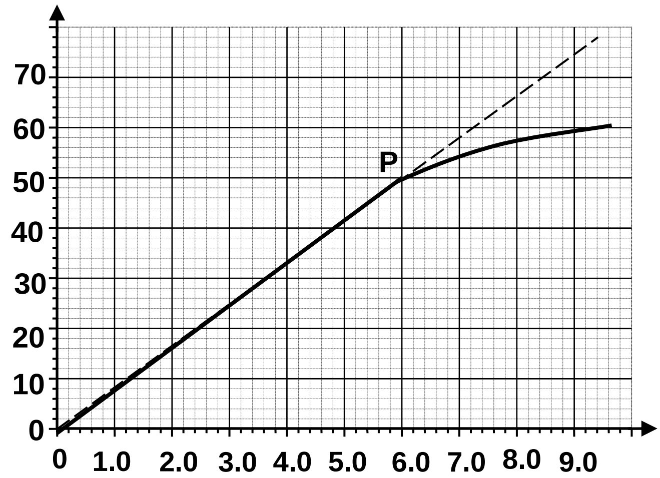
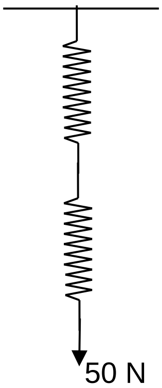


Fig. 4.2

1. Identify point P.

P is limit of proportionality .... [1]

2. Two identical springs, each with a force-extension graph as shown in Fig. 4.2, were connected end to end with a load of 50 N applied to one end as shown in Fig. 4.3.



Calculate the equivalent spring constant of the setup.

$F = kx$

$50 = k(0.012)$

$k = 4.2 \times 10^3 \text{ N m}^{-1}$

[2]

spring constant = ………………….. N m^{-1}

Marker's comments: Several students used 12 (mm) instead of 0.012 (m) in their calculation. A few students thought that the 50 N force is shared by the two springs. Alternative answer is to calculate the K of 1 spring (using 50 N through each spring) and divide the value by 2 for the K of 2 springs in series.

3. The two springs are now connected in parallel as shown in Fig. 4.4.

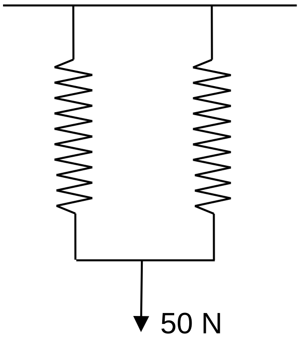


Fig. 4.4

By considering the forces experienced in each spring, calculate the equivalent spring constant of the setup.

$F = k' x$

$50 = k' \times 0.0030$

$k' = 17 \times 10^3$ N m^{-1}

spring constant = ………………….. N m^{-1}

Marker's comments: Several students used 3 (mm) instead of 0.003 (m) in their calculation. Alternative answer is to calculate the K of 1 spring (using 25 N through each spring) and double the value for the K of 2 springs in parallel. [2]

5 **(a)** **(i)** Define *work*.

Work is the product of a force and the displacement in the direction of the force.

Marker's comments: Many students wrote "distance" instead of "displacement". Several students seem to think that the force must be in the direction of the displacement.

[1]

(ii) A body of mass, *m* is lifted to a height *h* above its initial position at a constant velocity by a constant upward force *F* as shown in Fig. 5.1

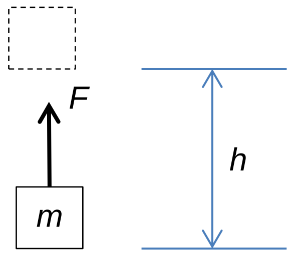


Fig. 5.1

Derive using the definition of work done, the formula $E_p = mgh$ for potential energy changes near the Earth's surface. [Show your explanations clearly. No marks will be awarded for pure derivation without explanations.] [2]

Since the mass is moving at constant velocity, the work done by the force is used to increase the E_p of the mass.
Since the mass is moving at constant velocity, F = mg.
Work done = $E_p = F \times h = mgh$.

Marker's comments: Some students tried to prove the formula by comparing the units. Others wrote that "since velocity is constant, acceleration must be equal to g." Several students did not explain why work done, W = gain in GPE, using the fact that KE remains constant. Quite a number of students wrote that the only force acting on the body is its weight.

(iii) Determine the power of the applied force when the mass of the body is 5.0 kg and the body is moving with a constant velocity of 3.0 m s^{-1}.

Power = F. v = 5.0 x 9.81 x 3.0
= 147 W

Marker's comments: Some students used $P = W/t = \frac{1}{2} m v^2 / t$, thinking that the body gain a certain amount of KE over a period of time t.

power = ………………….. W [2]

(b) A cyclist, together with his bicycle, has a total mass of 95 kg and is travelling with a constant speed of 20 m s^{-1} on a flat road. He then goes down the long slope, with a constant frictional force of 15 N along the slope, to point B which is 4.0 m vertically below the original height as shown in Fig. 5.2.

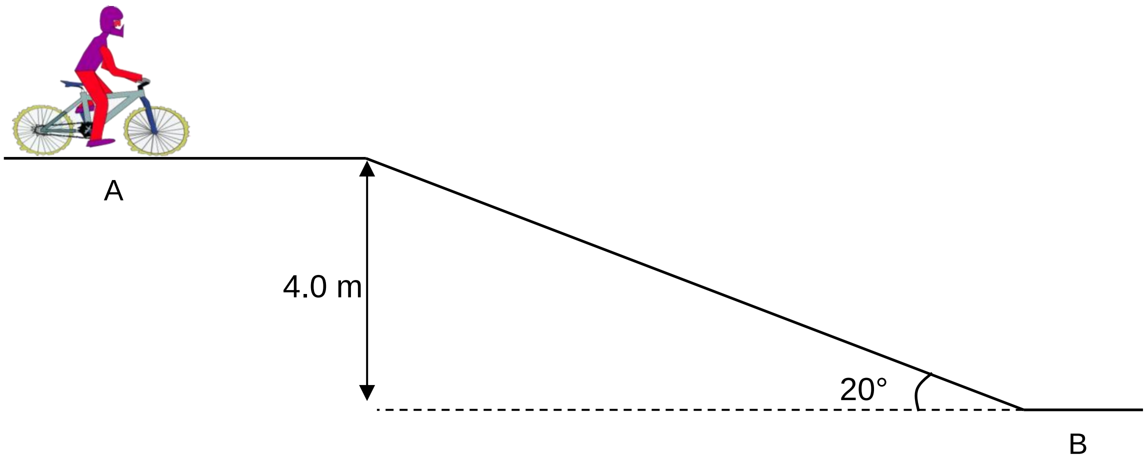


Fig. 5.2

Calculate

(i) the work done against friction along the slope,

Work done against friction = (4.0/sin20°) x 15
= 175.4 J

Note: Negative values are not accepted as this is work done against friction and not work done by friction.

work done against friction = ………………….. J [1]

(ii) the speed at point B given that the cyclist stoppd pedalling along the slope,

$\frac{1}{2} mv_B^2 = \frac{1}{2} mv_A^2 + mgh$ – Work done against friction

$\frac{1}{2} (95) v_B^2 = \frac{1}{2} (95) (20)^2 + 95(9.81)(4) - 175.4$

v_B =22 m s^{-1}

Marker's comments: Some students were careless and forgot to square v when calculating KE.

speed at B = ………………….. m s^{-1} [2]

(iii) Describe and explain the energy transformations taking place when the cyclist is travelling at constant speed on the flat road before reaching the slope.

Chemical energy of the man is converted to heat or thermal energy of the surrounding air / gears / road surface / tires or sound energy or thermal energy of the cyclist. There is no gain in kinetic energy as the cyclist is moving with a constant speed.

[2]

Marker's comments: Many students were describing the process where the cyclist moves down the slope, where GPE was converted to KE. A few students wrote that there was no energy transformation since KE remains constant.

– End of Paper –