Energy and Momentum 2A

Name : _____Answers___________

[00 Marks total]

All calculations are to be set out in detail. Marks are awarded for correct equations and clear setting out, even if you cannot complete the calculation.

1) A student (50kg) rides her bike(12kg) in a westerly direction at 8.0 m/s. There is a force due to friction and air resistance of 60N.

   a) What is the force she must provide?

      Forces must be balanced for constant velocity, $F_{provided} = 60N$ (1)

   b) If she rides her bike for 1 km west, what work has she done?

W = ?	W = F x s	
F = 60N	W = 60 x 1000	
s = 1000m	W = 6.00 x 10^4 J	(2)

(3 marks)

2) Whilst on excursion a physics student (62kg) went to Scitech and rode a bike on an exhibit that stated he exerted 1200 Joules in one minute. He knows his bike (15kg) at home provides a force due to friction and air resistance of 50N.

   a) How far over level ground can he go with one minute's worth of energy?

W = 1200 J	W = F x s	
F = 50N	s = W / F	(1 rearrangement)
s = ?	s = 1200 / 50	
	s = 24.0 m	(1)

(2 marks)

   b) The student finds that he can not go as far when riding up a hill, why is this?

      When riding up a hill, he must act against the acceleration due to gravity (1) as well the frictional forces, the steeper the hill the greater the force (1) required, so less distance covered for the same amount of energy.

(2 marks)

3) Explain how having a roo bar fitted to a car can be considered very dangerous to pedestrians or to the car's occupants in a crash involving something heavier than a kangaroo.

A car is made to have crumple zones that deform when hitting an object (1). Since impulse is constant (equal to change in momentum) this increases the time taken for the car to decelerate allowing the force on the occupants to be less (1). A roo bar could stop the crumple zones working, decreasing time and increasing force on occupants increasing chance of injury (1). (Formula helpful, I = Ft = constant, and is worthy of a mark)

(3 marks)

4) A person on a motorcycle (120kg) with a 28kW motor is at rest.

a) If she accelerates for 5 sec from rest, what is her velocity?

P = 28000W	P = W/t	
m = 120 kg	W = P x t	
$W = \Delta E_k$	W = 28000 x 5	
v =? ms^{-1}	$W = 1.40 \times 10^5$ J	(1 energy converted)
a = ?	$W = ½\ m \times v^2$	(1 $W = \Delta E_k$)
t = 5.00 s	$v = \sqrt{(2W / m)}$	(1 rearrange formula)
	$v = \sqrt{(2 \times 1.40 \times 10^5 / 120)}$	
	v = 48.3 ms^{-1}	(1)

(4 marks)

b) How far has the motorcycle gone in this time?

s = ?	v_{avg} = (v+u)/2=s/t	
u = 0.0 ms^{-1}	s = (v+u)/2 x t	(1 rearrange formula)
v =48.3 ms^{-1}	s = (48.3 + 0)/2 x 5	
a = x	s = 242 m	(1)
t = 5.0 s		

(2 marks)

Club and golf ball pic

5) A golfer played a beautiful shot at a weekday golf competition. His golf ball, with a mass of 45.9 grams, was hit with a 0.500 kilogram club travelling at 30.0 ms^{-1}. The ball was given a velocity of 125 ms^{-1}.

a) What is the change in momentum for the ball?

$\Delta p = ?$ | $\Delta p = m\,\Delta v = m(v-u)$
$m = 0.0459$ kg | $\Delta p = 0.0459\,(125 - 0.0)$
$u = 0.0\ ms^{-1}$ | $\Delta p = 5.74\ kgms^{-1}$ (2)
$v = 125\ ms^{-1}$

(2 marks)

b) What is the velocity of the club after the collision?

$\Delta p_{club} = \Delta p_{ball} = -5.74\ kgms^{-1}$ | $\Delta p = m\,\Delta v = m(v-u)$
$m = 0.500$ kg | $v = \Delta p/m + u$ (1 rearrangement)
$u = 30.0\ ms^{-1}$ | $v = -5.74/0.500 + 30$ (1 sign)
$v = ?\ ms^{-1}$ | $v = 18.5\ ms^{-1}$ (2)

(4 marks)

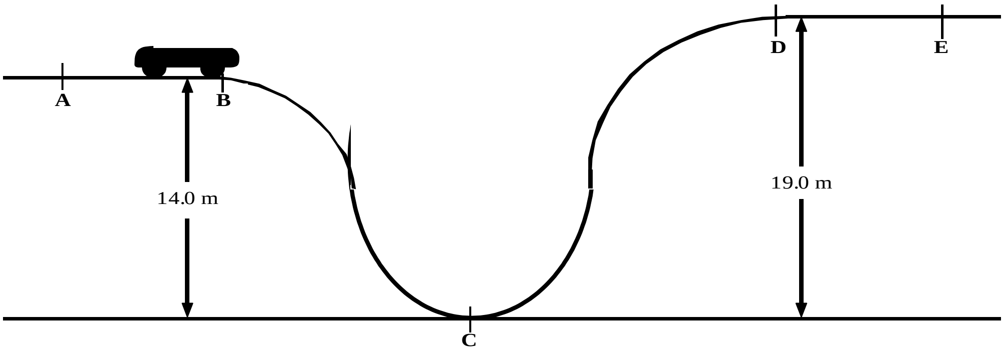
c) If the collision took place over 2.20×10^{-3} of a second what is the average force that was exerted on the ball over this time?

$F = ?$ | $Ft = \Delta p_{ball}$
$t = 2.2 \times 10^{-3}$ s | $F = \Delta p_{ball} / t$ (1 rearrangement)
$\Delta p_{ball} = 5.74\ kgms^{-1}$ | $F = 5.74 / 2.20 \times 10^{-3}$
$F = 2.61 \times 10^{3}$ N (2)

(3 marks)

6) Consider an 80.0 kg carriage on a roller coaster ride as shown in the diagram below:

[15 Marks]



If the initial velocity of the carriage along AB is 12.0 ms^{-1}, calculate the following:

a) The carriage's kinetic energy along AB.

$E_{k\ at\ B}$ = ?
m = 80.0 kg
v = 12.0 ms^{-1}

$E_{k\ at\ B} = ½\ m\ v^2$
$E_{k\ at\ B} = ½\ 80.0 \times 12.0^2$
$E_{k\ at\ B} = 5760\ J = 5.76 \times 10^3\ J$ (2)

(2 marks)

b) The potential energy, relative to point C, of the carriage while it is moving along AB.

$E_{p\ at\ B}$ = ?
m = 80.0 kg
h = 14.0 m

$E_{p\ at\ B} = mgh$
$E_{p\ at\ B} = 80.0 \times 9.8 \times 14.0$
$E_{p\ at\ B} = 10976\ J = 1.10 \times 10^4\ J$ (2)

(2 marks)

c) The total energy the carriage has along AB.

$E_{total} = E_{k\ at\ B} + E_{p\ at\ B}$
$E_{total} = 5760 + 10976\ J$
$E_{total} = 16736\ J = 1.67 \times 10^4\ J$ (2)

(2 marks)

d) The velocity of the carriage at point C.

$E_{k\ at\ C} = E_{total} = 16736$ J | $E_k = ½ m v^2$
$m = 80.0$ kg | $v = \sqrt{(2E_k / m)}$ (1 rearrangement)
$v = ?\ ms^{-1}$ | $v = \sqrt{(2 \times 16736 / 80.0)}$
$v = 20.5\ ms^{-1}$ (2)

(3 marks)

e) The carriage's kinetic energy at D.

$E_{k\ at\ D} = ?$ | $E_{k\ at\ D} = E_{total} - E_{p\ at\ D}$
$E_{total} = 16736$ J | $E_{k\ at\ D} = E_{total} - mgh$ (1)
$m = 80.0$ kg | $E_{k\ at\ D} = 16736 - 80.0 \times 9.8 \times 19.0$
$h = 19.0$ m | $E_{k\ at\ D} = 1840\ J = 1.84 \times 10^3$ J (2)

(3 marks)

f) The velocity of the carriage along DE.

$E_{k\ at\ D} = 1840$ J | $E_{k\ at\ D} = ½ m v^2$
$m = 80.0$ kg | $v = \sqrt{(2E_{k\ at\ D} / m)}$ (1 rearrangement)
$v = ?\ ms^{-1}$ | $v = \sqrt{(2 \times 1840 / 80.0)}$
$v = 6.78\ ms^{-1}$ (2)

(3 marks)

7) A 48.0 kg physics student, after watching the Olympics last year, has decided that he wants to join the Olympic Trampoline Team. He decides to try for the “Highest Jump” event. He manages to drag a 1.00 m tall trampoline to the base of a 9.00 m high cliff. He climbs to the top, closes his eyes and imagines the Gold Medal around his neck.

[13 Marks]

a) Using the trampoline as a reference point. What is the potential energy he possesses?

$E_p = ?$	$E_p = mgh$	
$m = 48.0$ kg	$E_p = 48.0 \times 9.80 \times 8.00$	
$h = 9.00 - 1.00 =$	$E_p = 3763$ J $= 3.76 \times 10^3$ J	(2)
$h = 8.00$ m (1)		

(3 marks)

b) He leaps off the cliff in perfect form, hitting the centre of the trampoline. What is his velocity at this point?

$E_{k\ gain} = E_{p\ lost} = 3763$ J	$E_k = ½\ m\ v^2$	
$m = 48.0$ kg	$v = \sqrt{(2E_k / m)}$	(1 rearrangement)
$v = ?\ ms^{-1}$	$v = \sqrt{(2 \times 3763 / 48.0)}$	
	$v = 12.5\ ms^{-1}$ down	(2)

(3 marks)

c) The trampoline exerts a constant resistive force of 7400N. How far does the trampoline stretch downwards before he is catapulted up into the air?

$W = 3763$ J	$W = (F_t - F_g) \times s$	(1 both forces)
$F_{tramp} = 7400$N	$s = W / (F_t - F_g)$	(1 rearrangement)
$F_{grav} = mg$	$s = 3763 / (7400 - (48.0 \times 9.8))$	
$F_{grav} = 48.0 \times 9.8$	$s = 0.543$ (if only F_t $s=0.509$ m)	(2)
$s = ?$		

(4 marks)

d) The trampoline absorbs some of the energy in accelerating him up, if the trampoline absorbs 25.0% of the energy in changing his direction, how high will he go?

$E_p = E_{original} \times 75\%$	$E_p = mgh$	
$E_p = 3763 \times 0.75$ J	$h = E_p / mg$	(1 rearrangement)
$m = 48.0$ kg	$h = (3763 \times 0.75) / 48.0 \times 9.8$	(1 for %)
$h = ?$ m	$h = 6.00$ m	(1)

(OK, yes this is 75% of height, so full marks if worked that way)

(3 marks)