Motion, Forces and Energy Test

Total marks: 52

1. A rider & bicycle has a combined mass of 45·6 kg which has a change of speed from 2.85 ms^{-1} to 4.912 ms^{-1}. Calculate and state the gain or loss in kinetic energy. [2]

$\Delta KE = \frac{1}{2}m(v^2 - u^2)$
$= \frac{1}{2} \times 45.6 (4.912^2 - 2.85^2)$
$= 365J$ increase

2. An electric motor uses 2400 J of electrical energy in 15.0 seconds. Calculate the power rating of the motor. [2]

change to one minute to make this a 2-mark question?

$P = \frac{W}{t} = \frac{2400}{15} = 160\ W.$

3. Parents of young children but a swing set for their children. The swings rests 0·85 m above the ground and has a mass of 2·4 kg. The swing set comes with the warning shown below: [7 marks]

> **ACME SWINGSET**
> **Safety warning:** It is unsafe for children heavier than 25kg to use this swing.

a. What is the tension in the rope when the swing is empty? [2]

$T = mg = 2.4 \times 9.8 = 23.52\ N$
$\simeq 23.5\ N.$

An older child whose mass is 35kg sits on the swing. As the rope is old it breaks.

b. Explain why the rope broke when the child sat on the swing: [1]

~~The ~~weigh~~ mass of the child was ~~bigg~~ larger than the limit mass~~ ?

don't like this.

c. What was the potential energy of the swing and child? when the rope broke? [2]

$PE = mgh = (35+2.4) \times 9.8 \times 0.85$
$= 311.542\ J$
$\simeq 312\ J.$

d. How long does it take the child to fall to the ground? [2]

$s = \frac{1}{2}gt^2 \Rightarrow t = \sqrt{\frac{2s}{g}} = \sqrt{\frac{2 \times 0.85}{9.8}} = 0.416\ s.$

Yeah sorry, I was working on year 10 stuff & got confused about impulse in the course!!

change to 'rubber' or more description for ESL students?

e. ‘Softfall’ is a rubberised substance used on the ground of playgrounds. Explain using physics principals why a child is less likely to be injured if they fall onto ‘Softfall’ compared to concrete: [2] 3 marks

space

It takes an impulse ~~equal~~ $(F \times t)$ equal to the childs momentum to bring momentum to zero. Softfall increases the time the child take to decelerate to rest. Since t increases, this reduces the average force F needed, thus reducing likelihood of injury

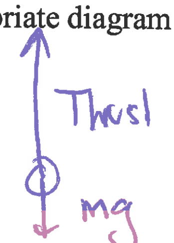
4. A model rocket with a mass of 600g exerts takes off vertically with a thrust force of 80N. It takes 0·45s for all its fuel to burn. [9 marks]

a. What is the acceleration of the rocket due to the thrust force? [2]

space

$a = \frac{\Sigma F}{m} = \frac{80 - mg}{m} = \frac{80 - 0.6 \times 9.8}{0.6} = 123\ m/s^2$

b. Draw an appropriate diagram so show the net acceleration on the rocket: [2]



Forces imbalanced $\Rightarrow$ net acceleration?

diagram shows force but not acceleration

Not sure about the question

c. What work is done in lifting the rocket to its maximum height? [5]

→ Not sure here ... more guidance ... needs thinking to a good question ...

~~Rocket accelerates for 0.45 s~~

~~$v = u + at$~~
~~$= 0.45 \times 123.53$~~
~~$= 55.59\ m/s$~~

$s = \frac{1}{2}at^2$
$= \frac{1}{2} \times 123.533 \times 0.45^2$
$= 12.5\ m$

Woops — don't need to know max height

Work done on rocket upwards
$= F \times s$
$= 80 \times 12.5$
$= 1992.6\ N.$
$= 1990\ N.$

Very tricky due to the 2 stages of flight. Work done in lifting rocket → converts to KE + PE. The work done by gravity slows rocket....

5. A car of mass 500kg travelling west at 25ms^{-1} crashes into the rear of a stationary truck with a mass of 6000kg. The vehicles lock together on impact. [8 marks]

a. What is the total kinetic energy of the system before the collision? [2]

$KE = \frac{1}{2}mv^2 + 0$

$= \frac{1}{2} \times 500 \times 25^2 = 156\,250 \text{ J}$

$\approx 156\,000 \text{ J}$

1 = car
2 = truck
$V_1 = V_2 = V$
$U_2 = 0$

b. What is the velocity of the car and truck immediately after the collision? [2]

$M_1U_1 + M_2U_2 = M_1V_1 + M_2V_2$

i. $M_1U_1 = (M_1+M_2)V$

ii. $V = \frac{M_1U_1}{M_1+M_2} = \frac{500 \times 25}{500 + 6000} = 1.92 \text{ m/s}$ in same direction

c. What is the total kinetic energy of the system after the collision? [2]

$KE = \frac{1}{2}(M_1+M_2)V^2$

$= \frac{1}{2} \times 6500 \times 1.9231^2$

$= 12000 \text{ J}$

d. Is this an elastic or inelastic collision? *Explain* [1]

No, mechanical energy is lost.

again ① ② is this too similar to Q5 scenario?

6. A stationary car of mass 950kg is hit from behind by a car of mass 1100kg travelling north at a constant velocity of 18·0ms^{-1}. The cars move off independently and the stationary car is pushed northward at a speed of 10·50ms^{-1}. — what about a bouncing question to introduce negative velocities/momentum [3 marks]

North = +ve

Show your working to calculate the velocity of the 1100kg car after the collision.

$M_1V_1 + M_2U_2 = M_1V_1 + M_2V_2$

i. $0 + 1100 \times 18 = 950 \times 10.5 + 1100\,V_2$

ii. $1100\,V_2 = 9825$

$V_2 = 8.93 \text{ m/s}$ North

Also, different to Q5.

7. A boy riding a skateboard on a footpath has a mass of 35·8kg with a velocity of 14·45ms^{-1} when he crosses over to a section of grass. The grass provides a retarding force of 50N for 2·5seconds against his motion, before he returns to the footpath. What is the velocity of the boy when he returns to the footpath? [4 marks]

Work done on boy : $W = F \times S$
$= 50 \times 2.5 = 125 \text{ J}$

No, too hard using energy.

$a = \frac{F}{m} = \frac{-50}{35.8} = -1.3966 \text{ m/s}^2$

$V = U + at = 14.45 - 1.3966 \times 2.5 = 10.958 \text{ m/s}$

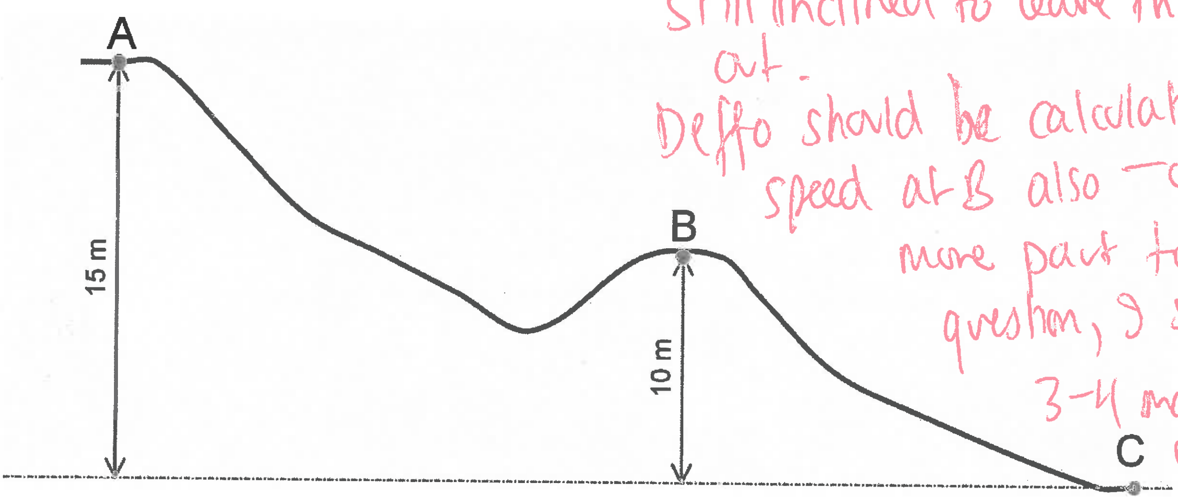
$= 11.0 \text{ m/s}$

8. On a visit to Adventure World John decides to go down the 'Giant" water slide. He and his rubber matt have a combined mass of 78·9kg. He pushes off **once** from point A with a force of 150N for 0·2s.

[11 marks]

Still inclined to leave this out.

Deffo should be calculating speed at B also - one more part to question, I suggest 3-4 marks PART (b)



a. Calculate the total mechanical energy of John when he reaches point B assuming no loss of energy to friction: [5] too many?

space

$W = F \times s = 150 \times 0{\cdot}2 = 30\ J$

$TME = 30 + mgh = 30 + 78{\cdot}9 \times 9{\cdot}8 \times 15$

$= 11628{\cdot}3 = 11600\ J$

v. small doesn't change answer

Same everywhere assuming no losses

c b. As John travels down the slide the associated friction causes a 2% loss of energy. What is John's velocity at point C? [3] too many if include new part (b)

space

$TME = 0{\cdot}98 \times 11628{\cdot}3 = 11395{\cdot}7\ J$

$\frac{1}{2}mv^2 = 11395{\cdot}7 \Rightarrow v^2 = \frac{11395{\cdot}7 \times 2}{78{\cdot}9}$

$v = 17{\cdot}0\ m/s$

d c. After several complaints about safety it was decided to add a 'slow down zone' at the end of the slide. What retardation force must this zone provide so that someone of John's mass comes to rest in no less that 1·6 s? [3]

like it

$F = ma$

$= m\left(\frac{\Delta v}{t}\right)$

$= 78{\cdot}9\left(\frac{17}{1{\cdot}6}\right)$

$= 838\ N$

So it doesn't confuse with a, how about "John panicks & tries to use his feet to slow down between B & C. & loses 5% of energy"

9. In Australia drivers and passengers in cars are required to wear seatbelts. By naming and using physics principals explain why it is unsafe to not wear a seatbelt during a collision. [3]

- Newton's first law says objects will continue in motion unless acted on by a force
- In a head-on crash, a large force will decelerate the car quickly
- If no force is present to decelerate the passenger, the passenger will continue forward, hitting the dashboard or windscreen of the car
- Seatbelt provides this force.

Other thoughts
- is there enough on power?
- should we put in 1 or 2 more FBDs
  → like draw a FBD for a parked car on an incline ...
- could add a weight/scales type question

~~Example~~ John ~~stands~~ is 80kg. What reading on a pair of scales in an elevator dropping at $2 m/s^2$