Test Review for Motion 6

Q1

(a) Describe, without calculation, how the *resultant* force acting on the car varies over this 10 second interval.

(a) decreases for the first four seconds ✓
zero for the remaining six seconds ✓

(b) Calculate the maximum kinetic energy of the car.

(b) $E_k = ½ \times 1.4 \times 10^3 \times 16^2$ ✓
$= 1.8 \times 10^5$ J ✓

Q1 continued

(c) At some time later, when the car is travelling at a steady speed of $30\,m\,s^{-1}$, the useful power developed by the engine is 20 kW. Calculate the driving force required to maintain this speed.

(c) (use of $P = Fv$ gives) $20 \times 10^3 = F \times 30$ ✓

$F = 670$ N ✓

Q2

A car accelerates at a steady rate of $2.5\,\text{m}\,\text{s}^{-2}$ along a straight, level road. The mass of the car is $1.3 \times 10^3\,\text{kg}$.

(a) Calculate the magnitude of the resultant force acting on the car.

(a) (use of $F = ma$ gives) $F = 1.3 \times 10^3 \times 2.5$ ✓

$= 3250\text{ N}$ ✓(3.25×10^3)

Q2 continued

(b) When the accelerating car reaches a speed of 2.2 m s^{-1}, the total force opposing the motion of the car is 410 N.

Calculate

(i) the driving force provided by the wheels,

(i) driving force = 3250 + 410 = 3660 N ✓

(ii) the power delivered to the wheels of the car.

(ii) (use of $P = Fv$ gives) $P = 3660 \times 2.2$ ✓

= 8100 W ✓

Q2

Explain how the total force opposing the motion of the car is affected when it is travelling up a hill.

(component of) car's weight opposes motion
[or overcomes gravity
or more work is done as car gains potential energy] ✓

Q3

A skydiver of mass 70 kg, jumps from a stationary balloon and reaches a speed of 45 m s^{-1} after falling a distance of 150 m.

(a) Calculate the skydiver's

(i) loss of gravitational potential energy,

(a)(i) (use of $E_p = mgh$ gives) $E_p = 70 \times 9.81 \times 150$ ✓
$= 1.0(3) \times 10^5$ J ✓

(ii) gain in kinetic energy.

(ii) (use of $E_k = ½mv^2$ gives) $E_k = ½ \times 70 \times 45^2$ ✓
$= 7.1 \times 10^4$ J ✓

Q3 continued

(b) The difference between the loss of gravitational potential energy and the gain in kinetic energy is equal to the work done against air resistance. Use this fact to calculate

(i) the work done against air resistance,

work done $(= 1.03 \times 10^5 - 7.09 \times 10^4) = 3.2(1) \times 10^4$ J ✓

(ii) the average force due to air resistance acting on the skydiver.

(ii) (use of *work done* = Fs gives) $3.21 \times 10^4 = F \times 150$ ✓

$F = 210$ N ✓

Q4

A packing case is being lifted vertically at a constant speed by a cable attached to a crane. The packing case has a mass of 640 kg.

(a) With reference to one of Newton's laws of motion, explain why the tension, T, in the cable must be equal to the weight of the packing case.

(a) resultant force on crate is zero ✓
forces must have equal magnitudes or size ✓
(but) act in opposite directions ✓
correct statement of 1^{st} or 2^{nd} law ✓

(b) The packing case is lifted through a vertical height of 8.0 m in 4.5 s.

Calculate

(i) the work done on the packing case,

(b)(i) work done $= F \times d = 640 \times 9.81 \times 8.0$ ✓
$= 5.0(2) \times 10^4$ J ✓

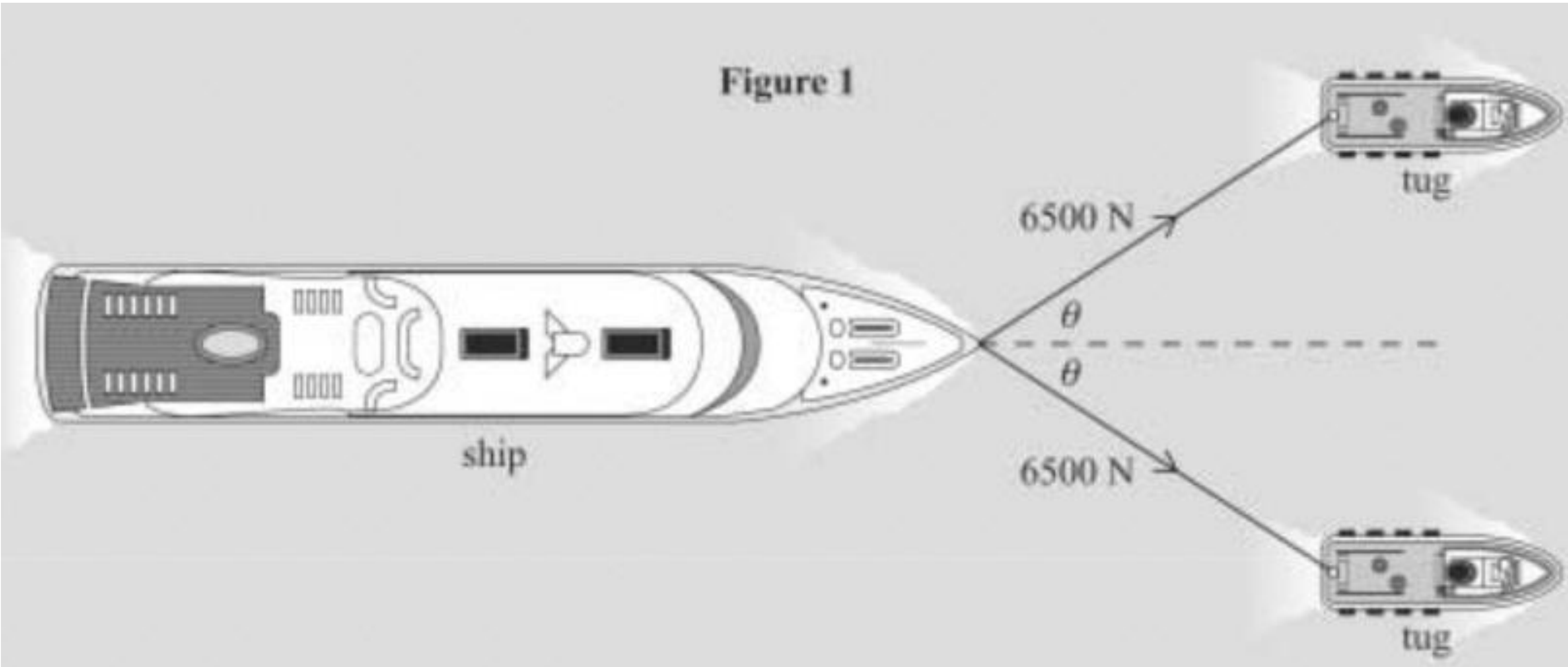
(ii) (use of $P = \dfrac{W}{t}$ gives) $P = \dfrac{5.02 \times 10^4}{4.5} = 1.1(2) \times 10^4$ W ✓

Q4 continued

(ii) the power output of the crane in this situation.

(ii) (use of $P = \frac{W}{t}$ gives) $P = \frac{5.02 \times 10^4}{4.5} = 1.1(2) \times 10^4$ W ✓

Q5



(a) The tension in each cable is 6500 N and the ship is moving at a constant speed of $1.5\,\text{m}\,\text{s}^{-1}$. When θ is equal to 35°, calculate

(i) the resultant force exerted on the ship by the cables,

(use of $F_H = F \cos\theta$ gives)
resultant force = $2 \times 6500 \cos 35$
resultant force = 11 000 N (10 649)

Q5 continued

(ii) the work done by the tension in the cables in one minute.

(use of work = force × distance gives)
work = 11 000 × 1.5 × 60
work = 990 000 J (958 408)

Q6

An athlete performs an experiment to measure the power developed as he runs up a flight of stairs. The athlete makes the assumption that the work done in climbing the stairs is equal to the gain in potential energy.

(i) State the measurements that would be needed to find the power developed by the athlete.

find students weight (**or** mass) ✓

measure (vertical) height (of stairs) ✓

time (how long it takes student to run up stairs)

(ii) Show how the measurements would be used to calculate the power developed as the athlete runs up the stairs.

using $E_p = mgh$ ✓

link measurements to quantities used to calculate E_p ✓

divide gain in E_p (**or** work) by time to get power ✓

Q6 continued

(iii) Explain why the power calculated by the athlete is likely to be less than the power actually developed.

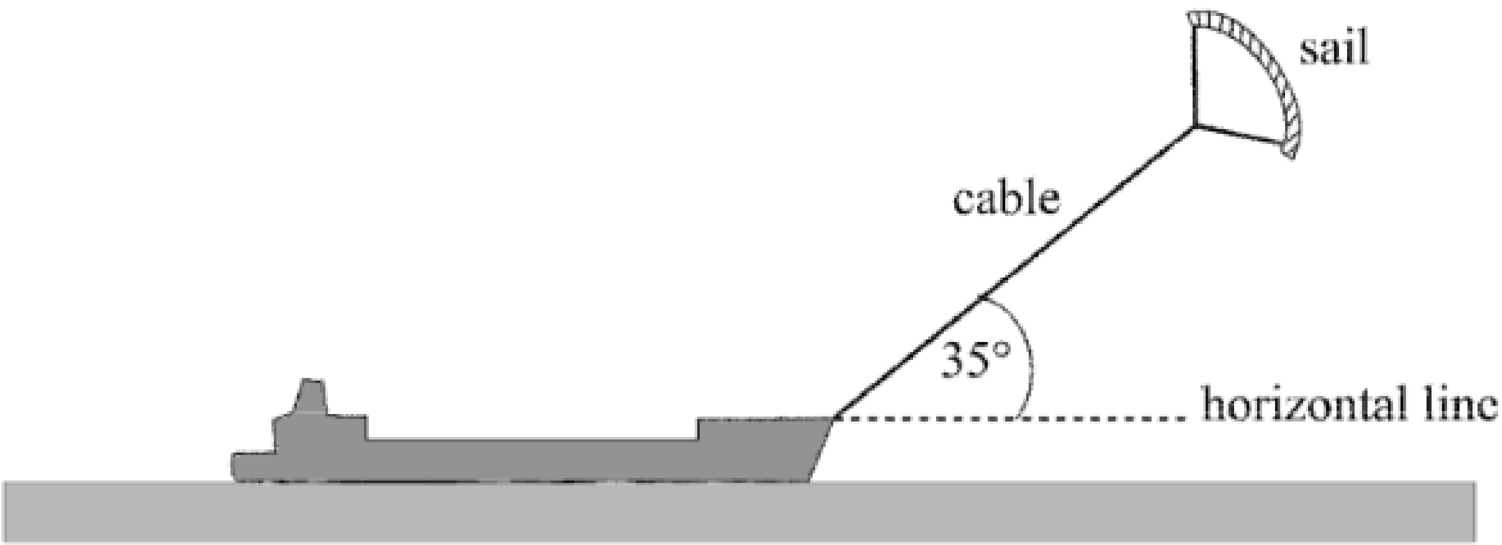
not all work done goes to E_p ✓

ignoring gain in E_k ✓
or ignoring movement
or ignoring fiction
or athlete gets hot
or body not 100% efficient

Q7

Figure 1 shows a ship fitted with a sail attached to a cable. The force of the wind on the sail assists the driving force of the ship's propellors.

Figure 1



The cable exerts a steady force of 2.8 kN on the ship at an angle of 35° above a horizontal line.

Q7 continued

(b) (i) Calculate the horizontal and vertical components of this force.

horizontal component (= 2.8 cos 35) = 2.3 (kN) (2293.6) ✓

vertical component (= 2.8 sin 35) = 1.6 (kN) (1606.0) ✓

(ii) The ship is moving at a constant velocity of $8.3\,m\,s^{-1}$ and the horizontal component of the force of the cable on the ship acts in the direction in which the ship is moving.
Calculate the power provided by the wind to this ship, stating an appropriate unit.

power = force × velocity **or** 2.3 kN × $8.3\,m\,s^{-1}$ ✓

= 1.9×10^4 (19037 or 19100) ✓ ecf

W (or $J\,s^{-1}$) ✓ (or 19 W (or $kJ\,s^{-1}$))

Q8

(a) A cricketer throws a ball vertically upwards so that the ball leaves his hands at a speed of 25 m s^{-1}. If air resistance can be neglected, calculate

(i) the maximum height reached by the ball,

(a)(i) (use of $v^2 = u^2 + 2as$ gives) $0 = 25^2 - 2 \times 9.81 \times s$ ✓

$19.6\, s = 625$ and $s = 32 \text{ m}$ ✓

(ii) the time taken to reach maximum height,

$$t = \frac{25}{9.81} = 2.5 \text{ s}$$ ✓

Q8 continued

(iii) the speed of the ball when it is at 50% of the maximum height.

(use of $v^2 = u^2 + 2as$ gives) $v^2 = 25^2 - 2 \times 9.81 \times 16$ ✓

and $v = 18\ \text{m s}^{-1}$ ✓

(b) When catching the ball, the cricketer moves his hands for a short distance in the direction of travel of the ball as it makes contact with his hands. Explain why this technique results in less force being exerted on the cricketer's hands.

time to stop the ball is greater ✓
∴ rate of change of momentum is less ✓
[or work done on ball is the same but greater distance ✓

Q9

A car accelerates at a steady rate of $2.5\,\mathrm{m\,s^{-2}}$ along a straight, level road. The mass of the car is $1.3 \times 10^3\,\mathrm{kg}$.

(a) Calculate the magnitude of the resultant force acting on the car.

(a) (use of $F = ma$ gives) $F = 1.3 \times 10^3 \times 2.5$ ✓

$= 3250\ \mathrm{N}$ ✓ (3.25×10^3)

(b) When the accelerating car reaches a speed of $2.2\,\mathrm{m\,s^{-1}}$, the total force opposing the motion of the car is 410 N.

Calculate

(i) the driving force provided by the wheels,

driving force = 3250 + 410 = 3660 N ✓

Q9 continued

(ii) the power delivered to the wheels of the car.

(use of $P = Fv$ gives) $P = 3660 \times 2.2$ ✓

(allow C.E. from(i))

$= 8100$ W ✓ (8.1×10^3)

Q10

A girl kicks a ball along the ground at a wall 2.0 m away. The ball strikes the wall normally at a velocity of 8.0 m s^{-1} and rebounds in the opposite direction with an initial velocity of 6.0 m s^{-1}. The girl, who has not moved, stops the ball a short time later.

(a) Explain why the final displacement of the ball is not 4.0 m.

(a) displacement is a vector ✓
ball travels in opposite directions ✓

(b) Explain why the average velocity of the ball is different from its average speed.

velocity is rate of change of displacement
average speed is rate of change of distance
velocity is a vector [or speed is a scalar]
velocity changes direction

Q10 continued

(c) The ball has a mass of 0.45 kg and is in contact with the wall for 0.10 s. For the period of time the ball is in contact with the wall,

(i) calculate the average acceleration of the ball.

$$a = \frac{(-6.0 - 8.0)}{0.10} \checkmark$$

$$= (-)140.\text{m s}^{-1} \checkmark$$

(ii) calculate the average force acting on the ball.

$$F = 0.45 \times (-)140 = (-)63 \text{ N} \checkmark$$

(iii) state the direction of the average force acting on the ball.

away from wall ✓
at right angles to wall ✓
[or back to girl ✓ ✓]
[or opposite to direction of velocity at impact ✓ ✓]