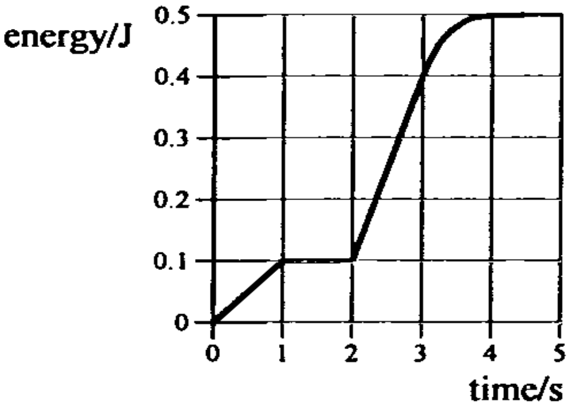
TOPIC 5: WORK ENERGY AND POWER QUIZ **Time: 20 minutes** **Score: / 10**

Name: ___________________________ **CG:** ______________

1 A car travels along a road at a constant speed of 20 m/s, its power output is 23 kW. The total resistive force on the car is proportional to the square of the speed. What power will be required for the car to travel at a constant speed of 40 ms^{-1}? (2018P1Q7)

2 A railway locomotive pulling a train delivers a constant power of 2.0×10^{6} W to the wheels. The resistive forces are constant at all speeds. The maximum speed that the train can achieve on a level track is 40 ms^{-1}
What is the resultant force accelerating the train when it is travelling at 10 m/s? (2012P1Q9)

3 (J94/1/6)
A bicycle dynamo is started at time zero. The total energy transformed by the dynamo during the first 5 seconds increases as shown in the graph.



Determine the maximum power generated at any instant during these 5 seconds.

4 A locomotive develops a constant power. The locomotive pulls a train of total mass 3.0×10^5 kg against a constant frictional force of 5.0×10^4 N. The acceleration of the train is 0.50 ms^{-2} when travelling at 10 ms^{-1}. What is the maximum speed that the train can achieve on a level track? (2014P1Q9)

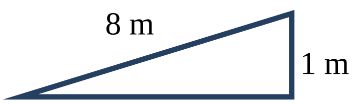
5 A ball of mass m = 2.60 kg, starting from rest, falls a vertical distance h = 55.0 cm before striking a vertical coiled spring, which compresses an amount Y = 15.0 cm. Determine the spring constant of the spring. Assume the spring has negligible mass and ignore air resistance.

spring constant = ……………….. N m^{-1} [3]

6 (N09/1/12)

A driving force of 200 N is needed for a car of mass 800 kg to travel along a level road at a constant speed of 20 m s^{-1}.

What power is required to maintain the car at this speed up a gradient in which the car rises 1 m for each 8 m of travel along the road?



power = …………………… W [3]

WEP Quiz Solutions

1 At 20 ms^{-1}, $P = F_{engine}v$, F_{engine} = 23000/20 = 1150 N = $F_{resistive}$

New F/1150 =$(40/20)^2$,
new F = 4600 N,
New P required = 4600x40 = 184000 W

2 P = Fv. At max v, F = $2.0 \times 10^6/40 = 5.0 \times 10^4$ N.
Since no acc, resistive force = F = 5.0×10^4 N

At 10ms^{-1}, $F_{engine} = 2.0 \times 10^6/10 = 2.0 \times 10^5$ N
Resultant force = $2.0 \times 10^5 - 5.0 \times 10^4 = 1.5 \times 10^5$ N

3 Maximum instantaneous power = maximum gradient of energy-time curve

$$= \frac{0.4 - 0.1}{3 - 2} \text{ \{where graph is steepest\}}$$

$$= \underline{0.3 \text{ W}}$$

4 When a = 0.50 ms^{-2}, $F - 5.0 \times 10^4 = 3.0 \times 10^5 \times 0.5$
$F = 2.0 \times 10^5$ N

$P = Fv = 2.0 \times 10^5 \times 10 = 2.0 \times 10^6$ W

At max speed, a = 0, so $F_{engine} = 5.0 \times 10^4$

Since P is constant, max v = $2.0 \times 10^6/5.0 \times 10^4 = 40$ ms^{-1}

5 {In the air: loss in GPE = Gain in K.E

When ball hits spring till Max compression:
Loss in K.E + Further loss in GPE = Gain in Elastic PE }

Let's consider the two points of comparison to be:
from the point when the ball is just released till the spring is in the maximum compression state:

Loss in GPE = Gain in Elastic Potential Energy

$mgh = ½ k y^2$ [1]

$2.60(9.81)(0.55 + 0.15) = ½ k (0.15)^2$ [1]

$k = 1587.04$

$= \underline{1590 \text{ Nm}^{-1}}$ [1]

6 <u>Along level road</u>,
to maintain a constant speed of 20 m s^{-1} {against resistive forces like air drag + friction},
power required, P_1 = Driving force Velocity of car = 200 x 20 = 4.0 kW [1]

<u>Up a slope</u>,
to maintain a constant speed of 20 m s^{-1}, {against resistive forces & gravity},
additional power required, P_2 = rate of gain of GPE = mgh ÷ time
= mg (x sin θ) ÷ time = mg (v sin θ)
= 800 x 9.81 x 20 x (1/8)
= 19620 W [1]

⇒ Total power required = P_1 + P_2 = 23620 W = <u>24 kW</u> [1]

Alternatively, (see force diagram below)
Total power required = (new driving force on slope) x velocity
= (resistive forces + *mg* sin θ) x (*v*)
= { 200 + (800 x 9.81 x (1/8)) } x (20)
= <u>24 kW</u>